TECHNICAL/AGENCY DRAFT RECOVERY PLAN

for the

Puerto Rican Parrot (*Amazona vittata*)

Prepared by

U. S. Fish and Wildlife Service,
Caribbean Ecological Services Field Office
Boquerón Field Office
Río Grande Field Office
Puerto Rico

for

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

April 2008

DISCLAIMER

Recovery Plans delineate reasonable actions that are believed necessary to recover and/or protect listed species. Plans published by the U.S. Fish and Wildlife (Service) are sometimes prepared with the assistance of recovery teams, contractors, state agencies, and other affected and interested parties. Plans are reviewed by the public and submitted to additional peer review before they are adopted by the Service. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks and may not represent the views nor the official positions or approval of any individuals or agencies involved in developing the plan, other than the Service. Recovery plans represent the official position of the Service only after they have been signed by the Regional Director or Director, as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

NOTICE OF COPYRIGHTED MATERIAL

Literature Citation:

U.S. Fish and Wildlife Service. 2008. Technical/Agency Draft Recovery Plan for the Puerto Rican Parrot (*Amazona vittata*). Atlanta, Georgia. 74 pp.

Copies of this recovery plan are available on the U.S. Fish and Wildlife Service website at:http://endangered.fws.gov/recovery/index.html#plans

Cover photo of Puerto Rican parrot by Tom Mackenzie

ACKNOWLEDGMENTS

The Service gratefully acknowledges the contribution of the following individuals in developing the Recovery Plan for the Puerto Rican parrot (*Amazona vittata*). Without their assistance, the completion of this plan would not have been possible.

The primary authors of this plan are:

Fernando Núñez-García
U.S. Fish and Wildlife Service
Southeast Region
Division of Federal Assistance

Pablo Torres-Báez
U.S. Fish and Wildlife Service
Río Grande Field Office

Additional thanks go to the following for their technical assistance, editing, and for drafting many sections of this document:

Jaime A. Collazo
U.S. Geological Survey
Biological Resources Division
North Carolina Cooperative Fish and Wildlife Research Unit,

Thomas White
U.S. Fish and Wildlife Service
Río Grande Field Office

Marelisa Rivera
U.S. Fish and Wildlife Service
Boquerón Field Office

EXECUTIVE SUMMARY

Current Species Status: The Puerto Rican parrot (*Amazona vittata*) is listed as endangered. This endemic species is the only native parrot in the United States and it is considered one of the ten most endangered birds in the world. Presently, a minimum of 25 individuals survive in the wild in the El Yunque National Forest (YNF) in eastern Puerto Rico and 10 in the Río Abajo Forest (RAF) in north central Puerto Rico. Two captive population facilities hold more than 225 individuals: the Iguaca Aviary and the José L. Vivaldi Aviary in eastern and west-central Puerto Rico, respectively.

Habitat Requirements and Limiting Factors: The Puerto Rican parrot is a frugivorous cavity nester seldom seen far from forests. The decline of the parrot and its restricted distribution are due to many factors, but mostly due to widespread habitat loss (e.g., deforestation.) Due to its nesting requirements, it depends on mature forests with large cavity forming trees. Many stands of cavity forming trees in the YNF are old enough to meet nesting requirements, and the potential for an increasing availability of cavities is high (Thompson-Baranello 2000). A large proportion of secondary forests occur in the northwestern karst region of the island (Helmer et al. 2002), and have been identified as the most suitable site for the reintroduction of the species (Trujillo 2005). Karst topography contains other types of cavities (e.g., cliff pot-holes) used in the past for nesting and these may contribute to a successful establishment of the species in the region. Within this region, the RAF, administered by the Puerto Rico Department of Natural and Environmental Resources was selected as the site for the establishment of the second wild population of parrots in the island. Twenty-two parrots were released in the RAF in November 2006, setting in motion efforts to establish a second wild population in the island.

At present, in addition to low numbers and a limited distribution, major threats to this species are nest competition and predation of eggs and chicks by pearly-eyed thrashers (*Margarops fuscatus*), predation of fledglings and adults by red-tailed hawks (*Buteo jamaicensis*), predation by rats (*Rattus rattus* and *R. norvegicus*), parasitism by warble flies (*Philornis pici*), and the impact of hurricanes. Other threats include competition for cavities with European and Africanized honeybees (*Apis mellifera*). Many of the threats are being controlled through management strategies. In the RAF, the species is threatened by predation by red-tailed hawks and broad-winged hawks (*Buteo platypterus brunnescens*).

Recovery Objective and Criteria: The objective of this recovery plan is to downlist and then delist the Puerto Rican parrot, ensuring its long-term viability in the wild.

A viable population is a reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. The number of individuals needed and the amount and quality of habitat required to meet these criteria will be determined for the species as one of the recovery tasks, and adjusted periodically during review of program accomplishments (i.e., milestones).

Downlisting the Puerto Rican parrot from endangered to threatened will be considered when:

1) A wild population in the Luquillo Mountains exists with a population size (yet to be determined) that exhibits vital parameters consistent with a trajectory towards maintenance. At present, population growth in the YNF could be expected if the breeding productivity is greater than or equal to 1.56 chicks per nesting attempt (average rate for the 1990s) and their survival rates should not drop below 90 percent for adults and 50 percent for juveniles. These rates assume that sub-adult survival rates are about 85 percent, age of first breeding is four years old, and at least 60 percent of the adults engage in reproduction each year (Figure 6). A higher number of breeding pairs is essential for vigorous population growth and historically has been stagnant at 2-6 pairs;
2) A second wild population in the northwestern karst region exists with a population size (yet to be determined) that exhibits vital parameters consistent with a trajectory towards maintenance;
3) The reintroduction or creation of at least a third wild population has been achieved in a suitable forested area in the island reflecting lessons and demographic expectations stemming from work with wild populations and release programs in the RAF and YNF;
4) Nesting and foraging habitats (yet to be determined) are protected to support growing populations.

Delisting

The Puerto Rican parrot will be considered for delisting when:

1) At least three interacting populations exist in the wild and population growth is sustained for 10 years after downlisting has occurred. This length of time will allow monitoring recruitment events and other population attributes in a species that has been characterized by highly variable reproductive and survival rates, at least in the YNF (Snyder et al. 1987, Muiznieks 2003, Beissinger et al. in press). Reviews of the recovery program prior to making a delisting determination will help define more explicitly the range of vital parameter values of a recovered population (see milestones 2 and 3).
2) Long term protection of the habitat occupied by each wild population is achieved.
3) The effects of disease and predation factors are controlled to allow for population viability.

Actions Needed:

1. Protect and manage the Puerto Rican parrot wild population.
2. Assess and protect current and future public and privately-owned habitat for the Puerto Rican parrot.
3. Maintain and manage the captive flocks.
4. Release captive produced parrots to augment the wild population and establish additional wild populations.
5. Establish additional wild populations as defined in the criteria.
6. Continue public awareness and education programs, and enforce existing laws to promote support for the recovery program.
7. Refine recovery criteria.

Implementation Participants: The U.S. Fish and Wildlife Service, U.S. Forest Service, and Puerto Rico Department of Natural and Environmental Resources are participants and partners in implementing the recovery actions deemed necessary for the Puerto Rican parrot.

Estimated Costs of Recovery:
(Dollar amounts listed are in thousands of dollars)

Year	Action 1 Protect and Manage the Puerto Rican parrot wild population	Action 2 Assess and protect current and future public and privately-owned habitat for the Puerto Rican parrot.	Action 3 Maintain and manage the captive flocks.	Action 4 Release captive produced parrots to augment the wild population and establish additional wild populations.	Action 5 Establish a third wild population.	Action 6 Continue public awareness and education programs, and enforce existing laws to promote support for the recovery program.	Action 7 Refine recovery criteria.	Total
FY08	119	30	603	237	2	5		996
FY09	121	30	613	230	4	3		1,001
FY10	126	32	623	269		5		1,055
FY11	130	32	633	233	60	4	12	1,104
FY12	135	34	643	277	65	5		1,159
FY13	143	34	654	237	70	5		1,143
FY14	150	36	664	287		6	15	1,158
FY15	152	36	674	242		5		1,109
FY16	157	38	684	297		6		1,182
FY17	161	38	694	247		5		1,145
FY18	165	40	704	305		6		1,220
FY19	170	40	714	255		5		1,184
FY20	175	42	724	320		6		1,267
TOTAL	1,904	462	8,627	3,436	201	66	27	14,723

Date of Recovery: Downlisting could be initiated in 2020, if criteria are met. Progress towards recovery will be reviewed on a timetable defined by recovery milestones. Milestones will trigger a review of accomplishments and incorporation of adjustments to the recovery program. In the short-term, that is, between 2008 and 2011, four milestones are proposed (refer to Recovery Milestones below). The milestones are set within the timeframe encompassed by the full implementation of the reintroduction program in the karst region, which started in 2006 and scheduled to last 5 years. A Population Viability Analysis for the YNF population is scheduled for 2008, or three years after the most recent analysis (Beissinger et al. in press), and again in 2011, to conduct a comprehensive evaluation of the status of the two wild populations (i.e., El Yunque and Río Abajo Forests). In 2011, adjustments to the recovery program, including setting new milestones, contained in a revised recovery plan will lead recovery efforts to meet the species' downlisting recovery criteria in 2020.

<u>Recovery Milestones:</u>

1. The Genetic Management Plan for both aviaries and wild chicks from YNF was implemented in 2005. Review aviary accomplishments in 2008 and 2011 and revise aviary protocols accordingly. Review effectiveness and use (e.g., pairings, candidates for release) of Genetic Management Plan as a recovery tool.
2. Reintroduction of Puerto Rican parrots in the RAF began in 2006. Conduct demographic analyses and review of the reintroduction program in 2011.
3. Conduct Population Viability Analyses for the YNF population in 2008 and 2011, and evaluate effectiveness of release program.
4. Complete evaluation and selection of prospective reintroduction sites for a third wild population by 2011, and develop and implement plans to sustain new release program.
5. Review and update the Recovery Plan in 2013 as new information is gained to include updated actions, costs, and criteria for delisting.

TABLE OF CONTENTS

PART I. INTRODUCTION

Background

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (ESA), establishes policies and procedures for identifying, listing and protecting species of wildlife that are endangered or threatened. The ESA defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

The Puerto Rican parrot was listed as endangered throughout its range in 1967 (32 FR 4061) and received federal protection with the passage of the ESA in 1973. The Secretary of the Interior is responsible for administering the ESA's provisions as they apply to this species. Day-to-day management authority for endangered and threatened species under the Department's jurisdiction has been delegated to the Service. To help identify and guide species recovery needs, section 4(f) of the ESA directs the Secretary of the Interior to develop and implement recovery plans for listed species or populations. Such plans are to include: (1) a description of site-specific management actions necessary to conserve the species or population; (2) objective measurable criteria which, when met, will allow the species to be removed from the list of threatened and endangered species; and (3) estimates of the time and funding required to achieve the plan's goals and intermediate steps. Section 4 of the ESA, and regulations promulgated to implement its listing provisions (50 CFR Part 424), also set forth the procedures for reclassifying and delisting species on the Federal list of threatened and endangered species. A species can be delisted if the Secretary of the Interior determines that the species no longer meets the definition of endangered or threatened, based upon the following five factors listed in section 4(a)(1) of the ESA:

1. The present or threatened destruction, modification, or curtailment of its habitat or range;
2. Overutilization for commercial, recreational, scientific, or educational purposes;
3. Disease or predation;
4. The inadequacy of existing regulatory mechanisms; and
5. Other natural or manmade factors affecting its continued existence.

Further, a species may be delisted, according to 50 CFR Part 424.11(d), if the best scientific and commercial data available substantiate that the species or population is neither endangered nor threatened for one of the following reasons: (1) extinction; (2) recovery; or (3) original data for classification of the species were in error.

Once abundant and widespread throughout the Puerto Rican archipelago, the Puerto Rican parrot is presently one of the 10 most endangered birds in the world (Wiley et al. 2004). Habitat loss together with natural enemies is considered among the major causes for the precipitous decline of the species during the 20th century. Currently, a wild population of 25 to 28 individuals survives in the El Yunque National Forest (YNF), located within the Luquillo Mountains. Efforts to establish a second wild population began on November 19, 2006 with the release of 22 parrots in the Río Abajo Forest (RAF) located in the karst region of north central Puerto Rico. At present time, 10 individuals survive in the RAF.

Intensive efforts to protect and recover the species started in 1968, a year after the species was designated as endangered by the Secretary of the Interior. In 1973, the original captive rearing facility was established in YNF (previously known as the Caribbean National Forest) to prevent the immediate extinction of the species, and later, to rear and foster chicks into wild nests to increase breeding productivity. Given the regularity of hurricane disturbance, a second aviary (José L. Vivaldi Aviary hereafter J. L. Vivaldi Aviary) was created in 1993 in the RAF in the limestone lowlands of north-central Puerto Rico to safeguard the population (Lacy et al. 1989). This aviary is managed by the Puerto Rico Department of Natural and Environmental Resources (DNER). In 2007, the YNF captive population was relocated to a new facility now known as the Iguaca Aviary under the continued management of the U.S. Fish and Wildlife Service (USFWS). Presently, the two aviaries shelter over 225 parrots.

In 1987, Snyder et al. produced the book "The Parrots of Luquillo," an extensive monograph for the species. The book contains detailed information about the species that may not be covered in this plan. Citations to this book are made to place background information and recovery efforts in context. The reviewer may seek this reference for additional information.

Listing and Protection Status

The Puerto Rican Parrot was listed as an endangered species in 1967 (32 FR 4001) pursuant to the Endangered Species Preservation Act of 1966 (P.L. 89-669 Stat 926). Its protection was continued under the Endangered Species Conservation Act of 1969 (P.L. 91-135), and ultimately under the Endangered Species Act of 1973, as amended. Already by 1946, Puerto Rico Commonwealth regulations prohibited nest robbing and hunting in the YNF (Snyder et al. 1987). The Wildlife Law of 1970 and the Regulation to Govern the Management of Threatened and Endangered Species in the Commonwealth of Puerto Rico of 1985 strengthened and established the local legal basis for the protection of the parrot. The Commonwealth Wildlife Law 241 of 1999, the Regulation to govern vulnerable and endangered species (February 11, 2004) and the Regulation to govern the wildlife species, exotic species and hunting in the Commonwealth of Puerto Rico (February 11, 2004) further provided protection mechanisms to the parrots and all species in peril. Effective enforcement of laws and regulations began in 1970, shortly after Federal and Commonwealth governments began the recovery program.

Description

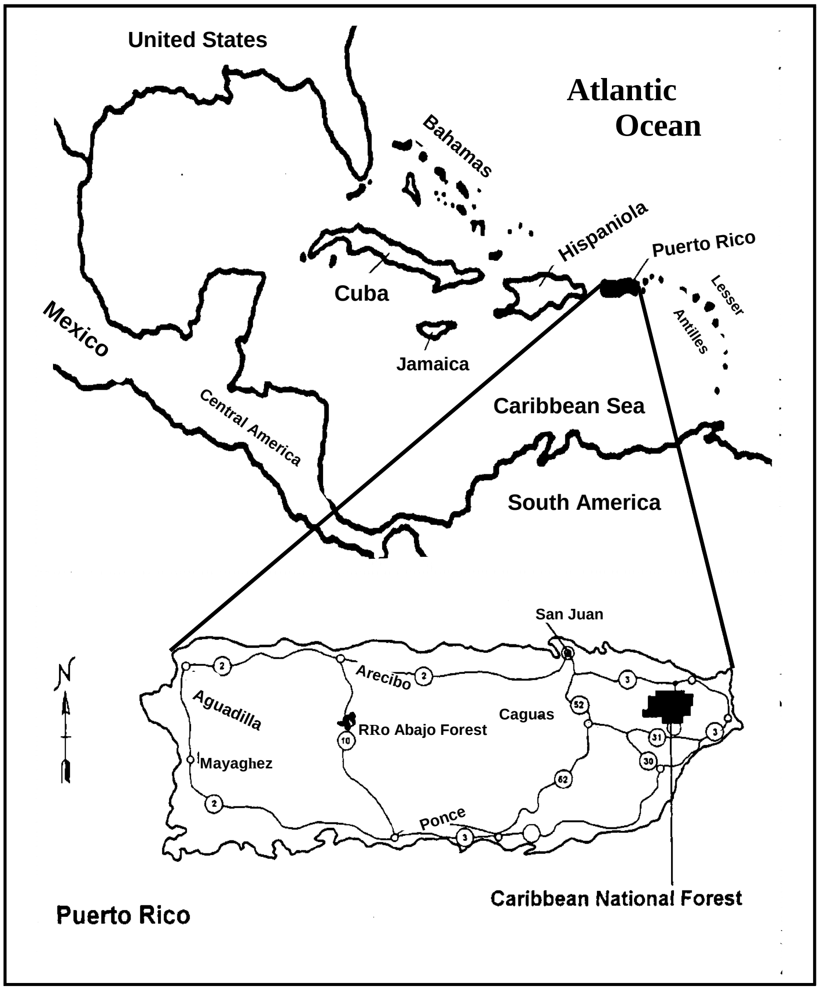
The Puerto Rican parrot, largely green with a red forehead and blue flight feathers, is one of nine extant *Amazona* parrots occurring in the West Indies (Wiley et al. 2004). Measuring about 29 centimeters (11 inches) in length and weighing about 270 grams (10 ounces), this species is one of the smallest in its genus, although it is similar in size to other *Amazona* in the Greater Antilles. Aspects of coloration suggest that it is most closely related to either the Jamaican black-billed parrot (*A. agilis*) or the Hispaniolan parrot (*A. ventralis*) (Snyder et al. 1987).

Taxonomic Status

The genus *Amazona* (family Psittacidae) consists of 34 species distributed between South and Central America and the Antilles and Mexico (White et al. 2005b). One species (*Amazona vittata)* is known from Puerto Rico, and two subspecies are recognized: *Amazona vittata vittata* (Boddaert), from mainland Puerto Rico and possibly offshore Vieques and Mona Islands, and *Amazona vittata gracilipes* (Ridgway) from Culebra Island (now extinct). The *gracilipes* adults were similar to *vittata*, but smaller, and with relatively smaller, more slender feet. (Forshaw 1978). The Puerto Rican parrots were last recorded on Culebra Island in 1899 when A. B. Baker collected three specimens (Snyder et al. 1987).

Distribution and Population Trends

The Puerto Rican parrot is currently present in the wild in both YNF and RAF, albeit currently as a recently reintroduced population in the latter (Map 1). All indications suggest that the parrot was once abundant and widespread on the Puerto Rican Archipelago's major islands (Snyder et al. 1987). The size of historical populations is highly speculative, but may have exceeded a million individuals. The parrot population probably remained reasonably stable until about 1650, when the human population began to increase rapidly. The decline assumed catastrophic proportions in the latter half of the l9th and early 20th centuries when most deforestation of the island took place (Birdsey and Weaver 1982, Snyder et al. 1987). By the early 20th century, the species had disappeared from all of the offshore islands and was restricted to five known areas on the mainland. By about 1940, the only remaining population was in the Luquillo Mountains of eastern Puerto Rico, the largest area of native vegetation left on the island. A summary of all population counts in the Luquillo Mountains since 1954 is presented in Appendix 1.



Map 1. Map of the Caribbean archipelago showing the location of Puerto Rico and the YNF (Caribbean National Forest) and Río Abajo Commonwealth Forest on the island.

Since 1973, the population has increased one percent annually (λ = 1.01, Figure 1). Over the last 10 years, however, there has been an annual decrease of eight percent (λ = 0.92). The number of wild parrots has never surpassed 47 birds, and currently stands at a minimum of 25 individuals (Table 1). Due to the nature and behavior of these parrots, surveying the population is challenging. Surveys are regularly conducted in areas currently used by parrots and areas also used by parrots in the past. However, we cannot assume that all individuals are always counted because birds have been known to use other areas in the YNF or adjacent areas in which their presence is sporadic and unpredictable. The most abrupt change in population numbers since 1973 was caused by hurricane Hugo in 1989. It reduced the wild population size from 47 to about 23 individuals. Increases in the number of wild parrots have not been followed by proportional increases in the number of breeding individuals, which has never exceeded 12 (Figure 1, Table 1). Prevalence of low numbers of individuals over a long period of time could lead to problems associated with genetic depression (e.g., survival, reproduction), as documented for other endangered species (e.g., Guam rail, Haig and Ballou 1995).

Judging by measurable parameters like fertility and hatching success of the wild population over a 30-year period, there is as yet no clear indication of such problems (Haig et al. 2004). However, Beissinger et al. (in press) provide documentation regarding egg hatchability that might indicate inbreeding effects in the Puerto Rican Parrot, drawing attention to the importance of a genetic management plan and recovery actions to minimize this problem. Fertility of wild nesting pairs ranged from 66 percent to 100 percent from 1991 to 2002 (Muiznieks 2003, Wunderle et al. 2003).

Table 1. Number of Puerto Rican Parrots counted during pre-breeding, post-breeding counts from 1973 to 2007 at the YNF, and the number of breeding individuals.

Year	Pre-breeding Counts	Post-breeding Counts	Number of breeding individuals
1973	16		6
1974	16		4
1975	14		10
1976	17		8
1977	18		6
1978	19		8
1979	25		8
1980	18		6
1981	19		8
1982	18	29	8
1983	25		8
1984	29		8
1985	25	35	8
1986	29	31	8
1987	29		8
1988	28		6
1989	38	47	10
1990	24	21	6
1991	24	30	12
1992	24	28	12
1993	34	42	12
1994	38	40	12
1995	33	44	10
1996	38	42	10
1997	40	40	10
1998	42	36	12
1999	38	38	10
2000	*	23	10
2001	28	31	10
2002	21	28	6
2003	24	17	10
2004	27	31	10
2005	27	17	8
2006	16	26	8
2007	18	25	8

* Pre-breeding survey not conducted

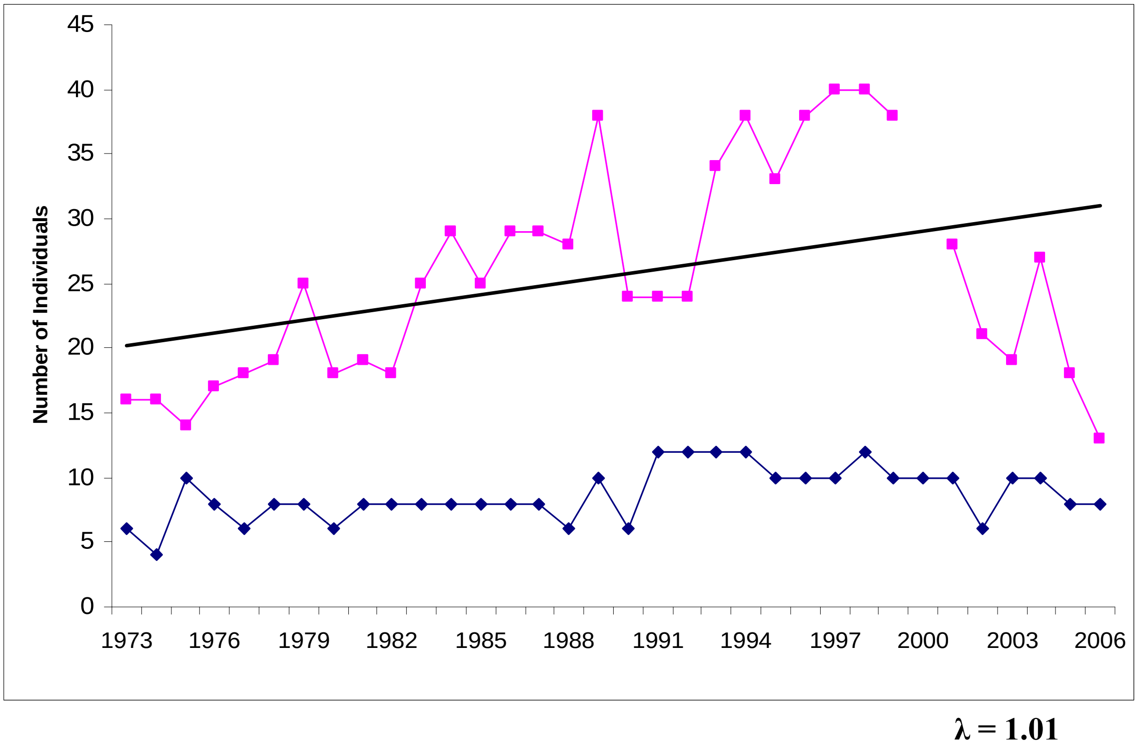


Figure 1. Number of Puerto Rican Parrots counted during pre-breeding surveys (March-April) in the YNF from 1973 to 2006. The number of breeding individuals recorded each year is also depicted. The average observed rate of increase (Caughley 1977) is expressed as the finite rate (λ).

Only 2 to 6 pairs in the wild population have attempted to breed each year during the history of the parrot recovery program (Table 1). This persistent low number of breeders was identified as the second most important factor, second only to hurricanes, limiting population growth in the YNF (Beissinger et al. in press). Table 2 summarizes information on breeding productivity from 1985 to 2006. Productivity from 1973 to 2002 was 1.48-chicks per nesting attempt (Table 3, Muiznieks 2003). Productivity peaked during the early 1990s when 1.88-chicks per nesting attempt were produced, but dropped again during the second half of the decade to 1.23. Variability in reproductive output remains high, but decreased from before 1989 to an average of 77 percent during the 1990s (Table 3). Variability in the 1990s was due to nest failures caused by ectoparasites, nest predation, and difficulties in fostering chicks to the wild during the second half of the 1990s (Muiznieks 2003).

Table 2. Breeding productivity of Puerto Rican Parrots from 1985-2006 in the YNF, Luquillo Mountains. A detailed account of each nest history was summarized by Wunderle et al. (2003).

Year	Total Fledglings	Number of Active Nests	Fledglings/nest attempt
1985	12	4	3
1986	9	4	2.25
1987	4	4	1
1988	8	4	2
1989	9	3	3
1990	2	3	0.666667
1991	7	6	1.166667
1992	11	6	1.833333
1993	15	6	2.5
1994	14	6	2.333333
1995	15	5	3
1996	7	5	1.4
1997	7	5	1.4
1998	9	6	1.5
1999	3	5	0.6
2000	8	5	1.6
2001	5	5	1
2002	2	3	0.666667
2003	8	5	1.6
2004	7	5	1.4
2005	6	4	1.5
2006	9	4	2.25

Table 3. Mean productivity (number of chicks per nesting attempt) of Puerto Rican Parrots from 1973 to 2002. Standard deviations and coefficient of variations are listed for the various time periods (Muiznieks 2003).

Year	1973-1989	1990-1995	1996-2002	1973-2002	1990-2002
N	76	34	34	113	68
Mean Productivity (SD)	1.41 (1.31)	1.88 (1.01)	1.23 (1.33)	1.48 (1.26)	1.56 (1.32)
Coefficient of Variation	0.93	0.54	1.08	0.85	0.85

Life History/Ecology

Snyder et al. (1987) described in detail all aspects of the life history of the Puerto Rican parrot. Descriptions in the following section are largely based on their work and previous versions and drafts of the Puerto Rican Parrot Recovery Plan (Service 1982, 1986, 1999).

Puerto Rican parrots mature at 3 to 5 years of age. Reproduction at age 3 has been documented in the Luquillo Aviary; age of first breeding in the wild population in YNF has been documented at age 4 (Meyers et al. 1996). Pair bonds between adult parrots are normally stable over the years, and pair members stay together at all times of the year, except when the female incubates and during the early nestling stages. The male assumes full foraging responsibilities for the pair during this time. Pair formation in the wild has not been observed in great detail, but involves bowing displays, in at least some cases.

Puerto Rican parrot pairs are very territorial, commonly engaging in fights with other pairs. Territories are defended, to some extent, year round and are extremely variable in size, sometimes consisting of only part of the nest tree and others extending many meters away from it. Non-breeding pairs, sometimes made up of sub-adults, have at times established territories. In all cases, newly territorial pairs have settled immediately adjacent to established pairs, a tendency that appears to explain the long-term stability of parrot nesting areas. When pairs are prospecting for nest sites, the males commonly take the lead. Once a cavity is selected, the parrots continue inspections and spend some time inside chewing the cavity interior. At about the time of egg-laying, females begin to roost in the nest hole overnight, a pattern they usually follow until the young fledge.

Copulations follow the usual New World parrot pattern; the male perches beside his mate, rests one foot on her back while gripping the perch with his other foot, and bending his tail under that of the female from the side. Cloacal contact is frequently accompanied by the male fanning one wing over the back of the female. Copulations are commonly preceded by the male feeding the female.

Incubation, performed solely by females, begins with or shortly after the laying of the first egg. Clutch size ranges from two to four eggs, but averages three eggs. The incubation period lasts about 26 days. Eggs hatch asynchronously, generally about 2 days apart. Nesting is highly synchronized seasonally, with almost all clutches produced in late February or early March, the driest part of the year and also the time of peak fruiting of sierra palms (*Prestoea montana*), the primary food of the species in the breeding season. Replacement clutches for eggs lost early in the breeding season were observed three times and induced six times (Snyder et al. 1987).

Young parrots hatch nearly naked with their eyes closed and take food almost immediately after hatching. Feeding is accomplished by regurgitation, and is performed by both adults, often working in tandem to feed all chicks in the nest. After about the first week of the nestling period, the female begins to forage with its mate for part of the day, increasing time away from the nest after 2 to 4 weeks. Most foraging takes place outside the nesting territory, with some pairs regularly flying as far as 1.6 kilometer (1 mile) to feeding areas. Chicks fledge at about 9 weeks of age, but some have taken as little as 8 weeks and as long as 11 weeks.

Habitat - Ecosystem Requirements

The extant wild parrot population may have retreated to the Luquillo Mountains because preferred lowland habitat was destroyed (Snyder et al. 1987). It is also possible that parrots always occupied this area and that the existing population originated from this stock. Regardless of its origin, there are many indications that habitat presently occupied by parrots in the YNF is suboptimal (Snyder et al. 1987, Muiznieks 2003, Beissinger et al. in press). Parrots currently concentrate their activities within the palo colorado (*Cyrilla racemiflora*) forest zone at its interface with the tabonuco (*Dacryodes excelsa*) forest zone. Primary stressors include high levels of avian predation on juveniles and adults and inclement weather conditions. Snyder et al. (1987) suggested that the parrot's close association with the palo colorado forest may be related to the availability of nest sites, and that its present limited distribution should not be considered typical of the species' historical distribution. The forest zones currently used by parrots (i.e., tabonuco, palo colorado trees) have a low plant species diversity compared to other forest zones in the YNF. Although the most commonly eaten foods by parrots are dominant in the vegetation, they can consume a wide variety of fruits, seeds, and leaves. A forest-wide assessment of food availability for parrots suggests that food is not a limiting factor (Thompson-Baranello 2000). Some observations suggest that the parrots are also using private lands in the Luquillo Mountain range, bordering the southern and northern parts of the YNF. Additional observations have been made a fair distance from the eastern boundary of the forest within the township of Naguabo.

Reasons for Listing/Threat Assessment

1. The present or threatened destruction, modification, or curtailment of its habitat or range.

Protection was afforded in view of the parrots' dramatic range contraction and population decline, particularly during the 20th century (Snyder et al. 1987). The destruction of the native forests was unquestionably a major factor influencing both parameters. By 1912, the island was more than 80 percent deforested, and of the remaining forests, only about 45,000 acres (ac) (18,220 hectares (ha)) remained in virgin condition (Murphy 1916). By 1922, only about 20,000 ac (8,097 ha) in the Luquillo Mountains remained forested, and nearly all of it had been cut to extract timber (Wadsworth 1949, 1951). Parrots are dependent on large diameter trees for nesting cavities (although one former population is known to have also used cliff pot-holes; Wiley 1980, Snyder et al. 1987). The limited availability of cavity trees was invoked to explain poor population growth and lack of new nesting areas (Snyder and Taapken 1977, Wiley 1985).

At the present time, wild parrots are restricted to the 11,274 ha YNF, located within the Luquillo Mountains, which encompass a total of 19,656 ha. During the past several decades, portions of the Luquillo Mountains outside of the YNF have become more forested due to a decline in agricultural practices on former pastures and farmlands. Since the mid-1950's, when the parrot population was determined to number only 200 birds, management activities by the responsible agencies, such as the US Forest Service, have included parrot recovery activities. These include locating parrot nest sites, improving nests, determining parrot range, and ensuring that other future forest management actions do not adversely affect parrots or parrot habitats. In 1986, the YNF Land and Resource Management Plan gave direction for long-term parrot habitat maintenance and improvement, and placed high emphasis on Puerto Rican parrot recovery.

2. Overutilization for commercial, recreational, scientific, or educational purposes.

Other factors that may have contributed to the decline of the parrot population in the island and the Luquillo Mountains were nest robbing, crop protection and hunting for food, road construction (e.g., PR-191), guerrilla warfare maneuvers, and radiation experiments (Snyder et al. 1987, USFWS 1999). Over the past 25 years, these factors have been reduced or eliminated completely. This species is listed and protected by C.I.T.E.S. (Appendix 1 Convention on International Trade in Endangered Species of Wild Fauna and Flora). We believe that overutilization for commercial, recreational, scientific or educational purposes should not be considered a threat at this time.

3. Disease or predation.

Red-tailed hawks are the primary avian predator of parrots, an important cause of juvenile and adult mortality (Snyder et al. 1987, Wiley et al. 2004, Nimitz 2005). There is also evidence that red-tailed hawks will enter nest cavities to kill parrots (Wiley 1980). Between 2000 and 2004, 40 captive-reared parrots were released in the Luquillo Mountains. The majority (54 percent) of the documented deaths were due to predation by red-tailed hawks, which claimed at least 21 percent of all released parrots, reaffirming the contention that this raptor was a primary source of mortality for parrots (White et al. 2005a, USFWS unpubl. data).

Other predators affect parrot demography through their impact on breeding productivity (e.g., pearly-eyed thrashers (*Margarops fuscatus*), black rats (*Rattus rattus*)), but intense management practices have curbed their impact. Pearly-eyed thrashers, which were not present in notable numbers in the YNF until the 1950's (Snyder et al. 1987), harass breeding parrots to obtain nest cavities. Thrashers will also attack parrot eggs and nestlings while exploring unattended nests (Snyder and Taapken 1977). Since 1976, modifying nest sites for parrots and installing thrasher-preferred nest boxes close to parrot nests have largely controlled thrasher depredations. Consistent management protocols have been implemented to reduce the impact of thrashers on the reproductive success of wild parrots, including the use of cameras and active control (White and Vilella 2004). Black rats are normally controlled through the use of poison bait stations strategically located near active parrot nests.

Honeybees (*Apis mellifera*) compete with parrots for nest sites (Wiley 1980, Wiley 1985, Snyder et al. 1987, Lindsey et al. 1994). Although there is no record of honeybees evicting nesting parrots, they take over nest cavities after the breeding season. Often it has been difficult to maintain each of the modified or natural cavities available for prospecting breeding parrots, although currently nests are closed as soon as possible following the nesting season to avoid usurpation by honeybees. The threat posed by bees has been exacerbated since the arrival of Africanized honeybees. Late nesters may be particularly vulnerable to honeybees as occurred in 1994. In this instance, the rapid intervention of a nest guard and subsequent cleaning by US Forest Service (USFS) and USFWS staff personnel saved two parrot chicks.

Sometimes, parrot nests become infested with parasites such as the botfly (*Philornis pici*) and the soldier fly (*Hermetia illucens*). *Philornis* ectoparasitic larvae significantly retard development and can result in death of parrot nestlings and adults (Arendt 1985, Snyder et al. 1987, Arendt 2000). Soldier fly larvae have been implicated in the death of at least one, and possibly two, nestlings. Current nest management practices, such as the use of palo colorado wood chips as nest material in conjunction with the application of carbaryl insecticide (e.g., Sevin), have resulted in the reduction of the presence of insect larvae in nest material.

Other possible predators of parrots in the YNF are the federally listed Puerto Rican broad-winged hawk (*Buteo platypterus brunnuscens*), peregrine falcons (*Falco peregrinus*), and Puerto Rican boa (*Epicrates inornatus*). Although predation of parrots by broad-winged hawks has not been documented in the YNF, the deaths of at least 3 captive-reared parrots released in the RAF in November 2006 were attributed to this raptor. This is consistent with reports from Dominica, where broad-wings have been reported preying on chicks of the red-necked parrot (*Amazona arausiaca*; Christian et al. 1996). Boas are predators of parrot nestlings in Jamaica and Dominica (J. Wunderle, USFS, pers. comm., 2004, Koenig et al. 2007). The Puerto Rican boa is not very abundant in the YNF, although its poor detectability likely results in biased-low estimates of the population (Wunderle et al. 2004, Koenig et al 2007). Although vines are used by boas to access tree cavities (Wunderle et al. 2004), there have been no documented deaths of parrots caused by boas in the YNF.

4. The inadequacy of existing regulatory mechanisms.

The Puerto Rican parrot is currently protected by both Commonwealth and Federal regulations. In 1999, the Commonwealth of Puerto Rico approved the Law #241 known as the “Nueva Ley de Vida Silvestre de Puerto Rico” (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve and enhance both native and migratory wildlife species; declare property of Puerto Rico all wildlife species within its jurisdiction, regulate permits, regulate hunting activities, and regulate exotic species among others. The DNER approved in 2004 the “Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extincion en el Estado Libre Asociado de Puerto Rico” (Regulation # 6766 to Regulate the Management of Threatened and Endangered Species in Puerto Rico). The Puerto Rican parrot has been included in the List of Protected Species and designated as “critically endangered”. Based on the existence of local laws and regulations protecting the species, we believe that inadequacy of existing regulatory mechanisms should not be considered a threat at this time.

5. Other natural or manmade factors affecting its continued existence.

Additional stressors impinging upon the demography of Puerto Rican parrots are local weather conditions and hurricanes. Weather in the Luquillo Mountains is extremely wet and humid. Exposure to rain limits the adequacy of nesting cavities as chicks and eggs can be lost due to rainwater entering nest cavities (Snyder et al. 1987). Occasionally, parrot chicks also suffer from respiratory diseases acquired in the dampened nest environment. Recent management techniques and new nest design have reduced the incidence of such events (White et al. 2005b).

The dependence of parrots on natural vegetation for food, shelter, and nest sites makes them particularly vulnerable to the impacts of hurricanes (Wiley and Wunderle 1993). Reduced survival and increased movements in search of food were documented for captive-reared Hispaniolan parrots (*Amazona ventralis*) released in Parque Nacional del Este, Dominican Republic, in the aftermath of hurricane Georges in 1998 (Collazo et al. 2003, White et al. 2005c). Circumstantial evidence suggests that Puerto Rican parrots were forced to lowlands in search for food when major hurricanes hit the Luquillo Mountains earlier in the 20th century (Snyder et al. 1987). Given the small size of the wild population, a single strong hurricane could potentially wipe out the entire current wild population. The frequency of major hurricanes in Puerto Rico (category 3 or higher) is 3 every 100 yrs (Lacy et al. 1989). Hurricane Hugo, in September 1989, illustrated the possibility of catastrophic losses. The wild population in the YNF was reduced to 23, or nearly half of the 47 individuals reported before the hurricane. After a comprehensive review of the demography of parrots since 1973, hurricanes emerged as the single most important factor impeding population growth in the YNF (Beissinger et al. in press).

Conservation Measures

Since 1973, increasingly intense efforts have been made to protect and recover the species (e.g., Snyder et al. 1987, Wiley et al. 2004, White et al. 2005a). These efforts started with surveys that established the critical status of the species, and continued with research that identified threats and implementation of conservation measures to recover the species. They can be summarized in the following categories.

<u>Land Ownership and Management:</u> During the past several decades, portions of the Luquillo Mountains outside of the YNF have become more forested because of a decline in agricultural practices on former pastures and farmlands. Since the mid-1950's, when the parrot population was determined to number only 200 birds, U.S. Forest Service land management activities have included parrot recovery activities. These include locating parrot nest sites, nest improvements, parrot range determination, and ensuring that other future forest management actions do not adversely affect parrots or parrot habitats. In 1986, the YNF Land and Resource Management Plan gave direction for long-term parrot habitat maintenance and improvement, and placed high emphasis on Puerto Rican parrot recovery based on what was considered essential and potential habitat for the species.

The RAF is approximately 2,340 ha (5,850 acres) and is located between Dos Bocas Lake and the Tanamá River in the municipalities of Utuado and Arecibo. This moist limestone forest with very irregular topography, subterranean drainage, caves, natural depressions or sinkholes and haystack hills, all characteristic of karst geological development, provides suitable habitat for the release of the parrot. In 1989, the DNER entered into an agreement with the USFWS to manage the RAF consonant with future parrot recovery activities. Currently, interagency efforts are underway to work with private landowners to protect, enhance and restore suitable habitat for the Puerto Rican parrot outside the forest boundaries. A draft programmatic Safe Harbor Agreement is currently under development to guide these efforts and provide ESA assurances to landowners.

Efforts to Increase Nesting Success and Breeding Productivity: Before 1973, nesting success, defined here as a pair fledging at least one chick, ranged from 11 to 26 percent. Research and intensive management efforts soon after the recovery program started, subsequently improved this success rate to 81 percent (Snyder et al. 1987). Activities included improving the quantity and quality of available nest sites and controlling enemies. Since 1976, all pairs of parrots have utilized either created or rehabilitated nest sites that were designed or modified to prevent entry of water and to discourage entry of predators and competitors. Wunderle et al. (2003) summarized the history of wild nests from 1973 to 2000.

The limited availability of cavity trees has been invoked to explain poor population growth and lack of new nesting areas (Snyder and Taapken 1977, Wiley 1985). After hurricane Hugo, habitat modification efforts to create suitable nest sites were intensified. Parrots have accepted some of the modified cavities. Artificial nest cavities have been redesigned (White et al. 2005b), and since 2002, 4 out of 5 breeding pairs have used them successfully (i.e., fledged young). A redesigned nest was placed in a new location (i.e., no previously existing cavity) in 2002, and a pair began using it in 2003. Another such nest was placed in a similar site in 2004, and a different pair also successfully used this nest in 2006. These results are encouraging, not only in terms of implementing successful cavity improvements, but also in trying to entice parrots to nest in different locations (White et al. 2006). Thompson-Baranello (2000) suggests that many stands of cavity forming trees are old enough to meet nesting requirements in the YNF, and the potential for an increasing availability of cavities is high. Two recent improvements are currently contributing to and increase in wild nest success, namely, the provision of improved natural or artificial nest sites and refinement of nest guarding techniques using cameras (White and Vilella 2004, White et al. 2005b).

Increases in breeding productivity have also been achieved by fostering chicks from the aviary to the wild, by nurturing chicks weakened by problems in the field (e.g., disease, parasites) and returning them to the wild when healthy, and from released birds that have joined the breeding population (i.e., recruitment; White et al. 2005a; Figure 2). The number of fostered chicks in any given year (1-3) and frequency of such events, however, is constrained by the number of breeding pairs able to raise an extra chick and the synchronicity between wild and aviary breeding cycles (Collazo et al. 2000).

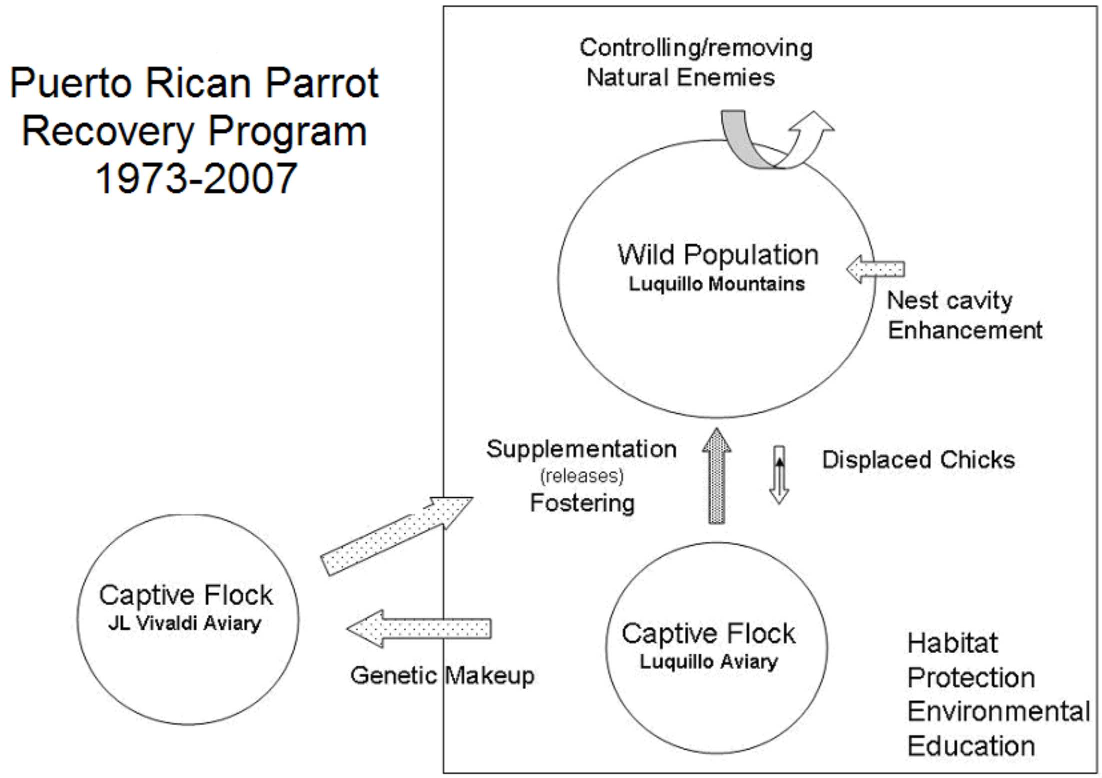


Figure 2. Puerto Rican Parrot recovery program at the YNF (Luquillo Mountains) from 1973 to 2007.

Recovery activities were implemented to promote population growth and preserve genetic diversity. Breeding productivity is enhanced by controlling natural enemies (e.g., thrashers, ectoparasites), improving tree cavities (e.g., depth), fostering or nurturing weak chicks in the aviary, and recruitment (e.g., released birds join breeding population). Survival of wild birds (including released birds) may also benefit from removing predators (e.g., red-tailed hawks). The J. L. Vivaldi aviary contributed birds for fostering and releases (2000-2002). Genetic management of the two aviaries was done independently, with the exception of transfer (founding purposes) of birds from the Luquillo to the J. L. Vivaldi aviary. Chicks from the wild might be brought to the aviary (e.g., displaced chicks) to increase genetic diversity. Habitat protection and environmental education programs are in place to complement population management.

Control of Predators/Competitors: Routine maintenance of nest cavities, habitat improvements, and nest guarding were and still are the primary techniques utilized to counter parrot predators. The use of poison baits has discouraged rat depredation. The problem of pearly-eyed thrasher takeovers of parrot nests was successfully resolved by converting nests into deep, dark structures with bottoms not visible from the entrances, characteristics repellent to thrashers, but not to parrots (Snyder et al. 1987, White et al. 2005b). Constriction of nest entrances and nest guarding has reduced raptor threats. Also, thrashers were provided nest boxes attractive to them, adjacent to parrot nest sites. By virtue of their territoriality, thrasher pairs serve as parrot nest guards, excluding other thrashers prospecting for nest sites from the vicinity of parrot nests.

Intensive honeybee swarm trapping efforts in breeding areas and covering nest entrances during summer, after the parrot breeding season, when most swarming takes place, reduces honeybee occupation of traditional and potential parrot nest sites. Hives, which become established in parrot nests, are routinely removed during the non-breeding season. Temporary closure of nest entrances has proved to be an effective method with no known adverse effects on the parrots.

The primary method of combating the warble fly threats has been frequent inspections of parrot chicks to determine severity of parasitism and the need for medical treatment (primarily surgical removal of maggots) of affected chicks. Recent prevention methods include application of carbaryl insecticide (Sevin ®) to the nest material.

<u>Establishment of Captive Stocks:</u> The precipitous decline of the species from the 1950’s to the early 1970s prompted the creation of a captive breeding program in 1973 to prevent the extinction of the species. It also represents a vital means to bolster the existing wild population and source of birds to initiate the second wild population. Initially, researchers took eggs from the wild and hand-reared the chicks in the Luquillo Aviary, but since 1976, most additions have been chicks salvaged from a variety of problems in the wild. In 1993, twelve Puerto Rican parrots were transferred from Luquillo to the J. L. Vivaldi Aviary. In 1995, a second group of 13 parrots was transferred. By then, the J. L. Vivaldi Aviary had already produced two Puerto Rican parrot fledglings. In 1996, for the first time, a chick born in the J. L. Vivaldi Aviary was fostered and subsequently fledged from a wild nest in the YNF. That event definitively established the versatility and importance of the J. L. Vivaldi Aviary. As of October 2007, the captive flock consisted of 235 parrots (149 in the J. L. Vivaldi Aviary and 86 in the Iguaca Aviary). Production in the previous Luquillo Aviary and J. L. Vivaldi Aviary is summarized in (Appendix 2).

Since the beginning of the captive breeding projects, captive flocks of Hispaniolan parrots were established as part of both aviaries. This stock of surrogate animals is important for testing potentially risky techniques that may be used on Puerto Rican parrots. These include marking procedures, multiple clutching, sequential removals of eggs, and more recently, development of a release strategy to bolster the wild population in the YNF and establish a second population by releasing captive-reared birds (Collazo et al. 2000, Collazo et al. 2003). Hispaniolan parrots have also been used as incubation surrogates and foster parents for Puerto Rican parrots. Their eggs and chicks have been used as emergency replacements for wild Puerto Rican parrot eggs and chicks threatened by various factors. Also, Hispaniolan parrot eggs and chicks are used to assess the aptitude of new pairs of Puerto Rican parrots for incubating their eggs and raising their own young.

Genetic Management: Genetic problems, although suspected (Snyder et al. 1987, Brock and White 1992, Beissinger et al. in press), have not been documented in the wild or captive Puerto Rican parrot populations. Recent analyses of fertility rates at the J. L. Vivaldi Aviary suggest there were no negative effects of maternal, paternal, or zygotic inbreeding on egg fertility or hatching rate in the reproductive success data (Daniels et al. 2001). Failure to find negative inbreeding effects remained true whether the dependent observation was each egg, the proportion of eggs in each year that were fertile or hatched, or the proportion of eggs in each pair's reproduction to date that were fertile or hatched.

Molecular work using microsatellite and ISSR markers suggests a high degree of relatedness among all parrots in wild and captive populations (Haig et al. 2004). Comparison of the same loci in Hispaniolan parrots indicated much lower levels of diversity in Puerto Rican parrots. Pedigree analyses including wild and captive birds (see Haig and Ballou 2002 for summary of techniques) indicated that the overall mean effective size (Ne) for the current living population of 43 male breeders and 40 female breeders over the past 2.65 generations was 82.9, thus Ne/N = 0.37. The closer this ratio is to 1.0, the more viable the population is. Hence, this result was not indicative of a robust population. This was also a most optimistic estimate as many founders (i.e., birds with no ancestors in the pedigree who have produced offspring) were assumed to be unrelated when, in reality, they most likely were closely related.

There were 37 birds defined as founders to the captive population (Haig et al. 2004). Pedigree analyses identified an additional 12 birds that could be considered founders if they bred (Figure 3). There were 178 birds that descended from these founders but the genetic contribution of individual founders has varied greatly, further reducing Ne. Gene diversity or heterozygosity among the living population was 0.93. Pedigree models begin by assuming 100 percent heterozygosity; hence this result represents a 7 percent loss of heterozygosity over a relatively short period of time. A general goal for the maintenance of genetic diversity has been identified as retention of 90 percent original heterozygosity for 200 years (Soule et al. 1986, Ballou and Foose 1996).

The number of founder genome equivalents (i.e., a measure of founder contribution and allelic diversity that potentially equals the number of founders in the pedigree) in the living population was low at 7.03. The gene drop model indicated this value could increase to 49 with better population management. Conversely, overall mean kinship (i.e., the mean of kinship coefficients between one individual and all other potentially reproducing members of a population; the higher the value, the more related birds are to each other) was 0.07 and the associated mean inbreeding coefficient was 0.04, neither of which suggests a problem with too close breeding. Unfortunately, this may be an overly optimistic view of mean kinship and inbreeding as the founders brought in from the wild were defined as being unrelated when they were likely related.

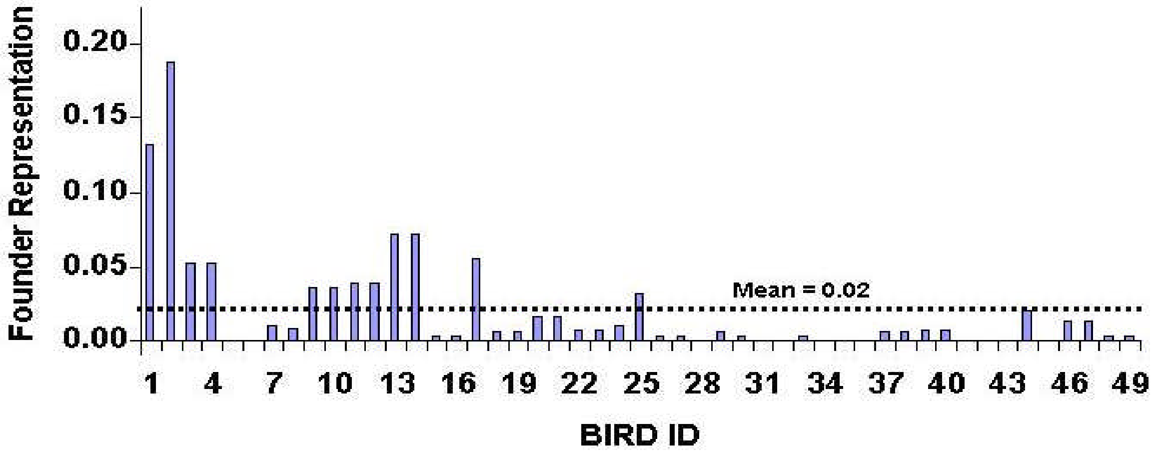


Figure 3. Founder contribution in Puerto Rican parrots. Those individuals whose contribution is under represented need to be selectively paired to increase their contribution to the flock (Haig et al. 2004).

The two captive flocks should be managed to minimize mean kinship as much as possible. Any parrot targeted for reproduction should be offered a choice of at least 3 individuals of equivalent mean kinship values. This scheme increases the probability of producing genetically, as well as behaviorally, compatible pairs.

<u>Monitoring the size of the wild population</u>: Population size is used to define a recovered population and to measure progress towards that goal, and for parrots, this parameter is estimated by conducting pre- and post-breeding counts in parrot activity areas (e.g., nesting area) by multiple observers. A count coordinator keeps track of numbers and movements to minimize duplicative counts. The reliability of counts was evaluated in 2003 using a "capture-recapture" approach taking advantage of instrumented birds in the population (see Williams et al. 2001). Detection probability was high (average = 0.96 in 4 counts). Counts within the sampling area were deemed accurate. The post-breeding population size was 28 (95% CI: 26-34). Scouting trips throughout the forest and surrounding lands are conducted prior to counts to determine if all birds are present in the sampled area. The idea is to minimize a potential spatial sampling bias. The approach outlined above will be used periodically to assess the reliability of counts, both in the YNF and RAF.

<u>Population Viability Analyses (PVA):</u> In June 1989, the Captive Breeding Specialist Group conducted a Puerto Rican parrot PVA workshop (Lacy et al. 1989). The analysis was based on the information and expert opinion of the parrot field biologists and population biology of the parrot. The aviary personnel provided information on the captive flock key to the development of a master plan for the captive population. The final report provided recommendations and identified management needs for the wild and captive populations. The proposal to establish a second captive and wild population to reduce the risk of losing the species to the effects of

catastrophic events was among the most important recommendations.

In 2003, updated demographic and environmental parameter estimates, and pertinent data from the 1989 PVA were used to conduct a second viability analysis assessing the status of the species from 1989 to 2002 (Muiznieks 2003). The process involved creating a Basic Scenario (BASE) model to assess population persistence and sensitivity analyses using program Vortex (see Appendix 3 for parameter values and Appendix 4 for description of the model). Model projections over 100 years were of a declining population (stochastic r = -0.066, Figure 4). The population went extinct in 997 of 1000 simulations and the persistence of the population was 0. The bleak prognosis results primarily from the low estimates of juvenile survivorship. Other parameters whose estimates changed to the detriment of the species (vis-à-vis more modest estimates used in the 1989 PVA, Appendix 5) were severity of catastrophes (changed from 25 percent to 50/60 percent) and age of first breeding (empirical evidence suggested that it is 4 or 5, not 3).

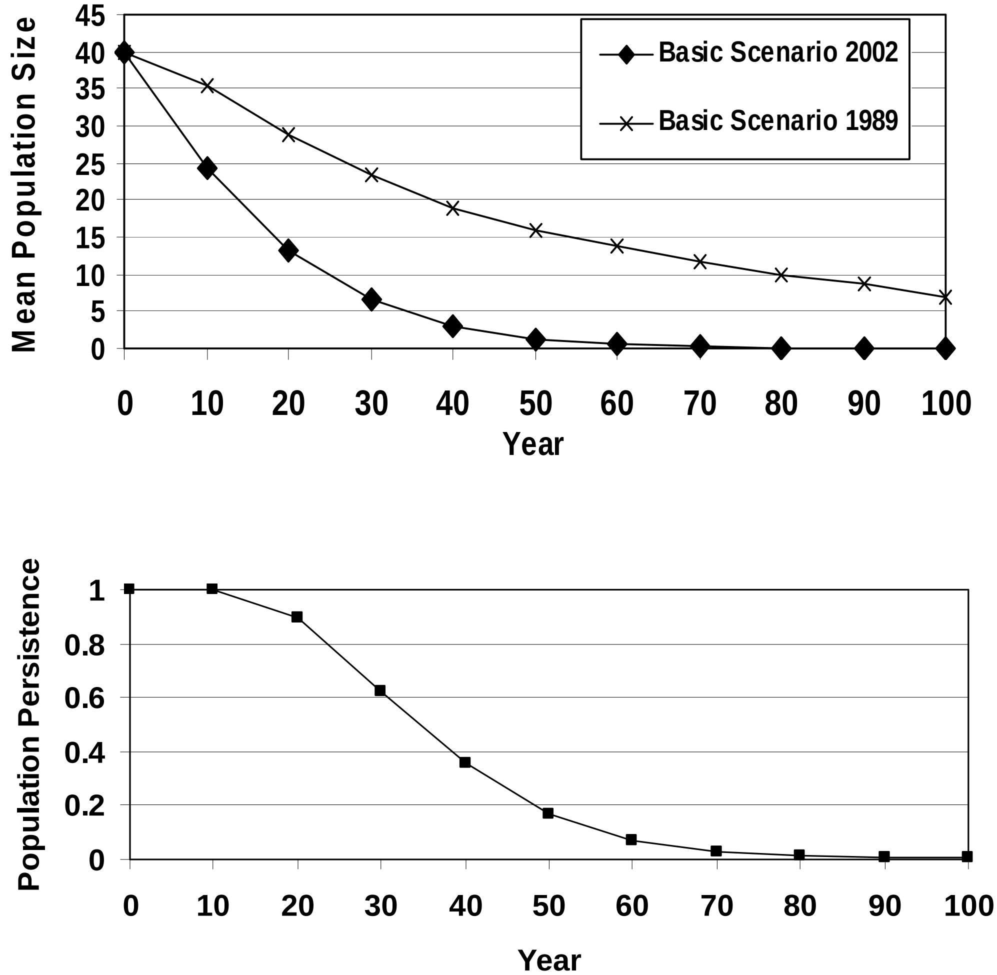


Figure 4. Population growth of Puerto Rican Parrots over 100 years using 1989 and 2002 PVA parameter estimates (e.g., juvenile survival, breeding productivity) contained in their respective BASE (see

Appendices 3-5). Graphs depict mean population size of combined (extant and extinct populations) simulations. Population persistence of Puerto Rican Parrots over 100 years for the 2002 BASE is depicted in the lower graph.

In 2006, comprehensive demographic modeling of limiting factors to Puerto Rican parrot population growth (1973-2000) was conducted by Beissinger et al. (in press). Many of the conclusions of their work were in harmony with previous assessments (Lacy et al. 1989, Muiznieks 2003). This is not surprising given that the analysis by Muiznieks (2003) and Beissinger et al. (in press) were based on the same dataset up to year 2000. However, for the first time, Beissinger and colleagues assessed the relative importance of various factors suspected of limiting population growth in the YNF, and raised the possibility that inbreeding might be limiting population growth. The primary factors maintaining the population bottleneck were hurricanes (and extreme rainfall events), via its influence on parrot survival, failure of a larger proportion of the adult population to breed annually, and inbreeding effects manifested in egg hatchability problems. Factors that contribute to stall population growth, but are not as important, included changes in annual survival of juveniles and adults, and individual nest failures.

Re-assessments of the population demography, status and persistence will be conducted in 2008 and 2011. These re-assessments are necessary because new data on vital parameters (e.g., juvenile survival), which also helps reduce parameter uncertainty (e.g., precision), help fine tune our understanding of the factors impinging upon the species demography and provide insights on how recovery actions might be modified to foster population growth and recovery. For example, data on juvenile survival since 2000, for wild or captive reared birds, suggest that annual survival rates have hovered around 0.40 vis-à-vis higher values (0.6) used in several assessments in the past (T. White, USFWS-Rio Grande Field Office, pers. comm. 2007).

Sensitivity analyses indicated that none of the values of 7 parameters used in the model scenarios yielded a positive, mean stochastic growth (see Appendix 6 for description of the analyses). Low juvenile mortality (32 percent) produced the best average stochastic growth rate (Figure 5). Available data suggest that, on average, juvenile survival is substantially lower (about 40 percent) than the 67 percent estimated from 1973-1989 (Snyder et al. 1987). It is likely that red-tailed hawk predation continues to be a major factor influencing juvenile survival (Snyder et al. 1987, White et al. 2005a), although concerns about some fledglings leaving the nest prematurely might be another factor contributing to lower juvenile survival (T. White, USFWS-Rio Grande Field Office, pers. comm. 2007). Certainly, the impact of red-tailed hawks has become easier to discern in recent years with the implementation of the release program and use of radio telemetry (Nimitz 2005, White et al. 2005a). It remains unclear whether red-tailed hawks are exacting a higher mortality rate on juvenile parrots in recent years as compared to prior to 1989. These results underscore the importance of better data to assess the relative importance of age-specific survival rates, particularly during non-hurricane years. Annual survival rates of parrots during the intervening years between hurricanes were not deemed important as a factor limiting population growth (Beissinger et al. in press)

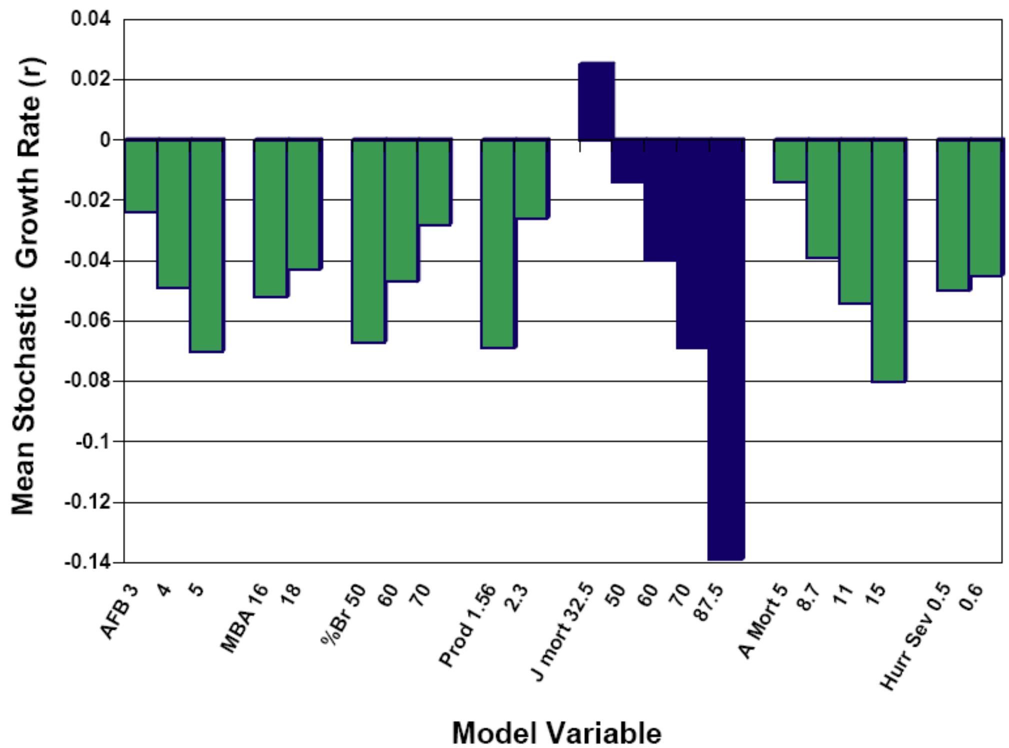


Figure 5. Sensitivity analysis of selected parameters influencing growth rates of Puerto Rican parrots. Mean stochastic growth rates were obtained by running 2,160 models, each replicated 1000 times, and sorting by the parameter of interest. Model components and parameter values are explained in Appendix 6.

Productivity levels recorded from 1990-95 (1.88) and 1996-2002 (1.23) resulted in a steady population decline with very low persistence (0.1-4 percent). Model outputs suggested that productivity (mean production per nesting attempt) somewhere between 2.5 and 2.75 chicks was needed to achieve population growth. Stated another way, a production of 12 chicks per year would be needed for population growth. On the basis of average production during the 1990s (1.56 chicks per nest attempt), it would take approximately 8 nests to meet annual production needs. Unfortunately, there have never been more than 6 active nests recorded since 1973 (Muiznieks 2003, Beissinger et al. in press). Even with a higher productivity (1.88 chicks per nest attempt), recorded from 1990-1995, there would be a need of at least 6 to 7 nests to produce 12 chicks per year.

At the average productivity between 1990 and 2002 (1.56 chicks per nest attempt), supplementation temporarily boosted the mean population size. The demographic benefits of supplementing birds were relatively short-lived, on the order of 10 to 20 years. If supplementations stopped, the mean population size declined. The mean population continued to grow only when supplementation was coupled with sustained high productivity (e.g., 2.75). Simulation results suggested that bolstering the population (i.e., 16 birds per release) over short or long periods of time will not change the demographic outlook of the species if released birds assume the same demographic pathway of wild birds (e.g., similar mortality threats and rates).

The status of the species is still precarious after 34 years of recovery efforts. Since 1973, the population has grown at a sluggish 1 percent annually (λ = 1.01 based on pre-breeding counts, Figure 1). Muiznieks (2003), using data up to year 2000, stated, that the species could face extinction in nearly 40 years. However, this trend has not been observed in recent years because of the implementation of new management practices and technology. The Service has documented a stable population at the YNF and will continue supplementing this wild population with juveniles produced in captivity. Furthermore, the Service, DNER and USFS initiated in November 2006 the establishment of a second population at RAF to prevent extinction. These factors were not included in the analysis conducted by Muiznieks (2003). Beissinger's et al. (in press) suggested, even in the absence of recent juvenile survival data, projected population numbers ranging from 18-22 within the next five years. The most recent pre-breeding count (2007) places the wild population in the YNF within the range of that projection already (Table 1).

Attaining the persistence and viability of the species is the ultimate goal of this recovery plan. These attributes, of course, will be attainable by promoting the existence of multiple, interacting populations, and growth rates (average stochastic r) consistent with maintenance or growth ($r \geq 0$). Specifying the number of individuals needed and the amount and quality of habitat required to achieve viability is not possible at this time due to the uncertainty associated with some parameters (see above) and threats and prevailing conditions impinging upon the extant population (Muiznieks 2003, Beissinger et al. in press). A more productive evaluation and reliable prognosis for recovery (i.e., delisting) will only be possible after a third population has also been established, coupled with efforts to reduce parameter uncertainty (e.g., precise estimates for vital parameters).

In the short-term, recovery efforts must be aimed at meeting or exceeding minimum demographic standards that will lead to sustained, positive stochastic growth rates, and ultimately, viability. The minimum levels for selected vital parameters for the YNF wild population under prevailing conditions can be gleaned from Figure 6.

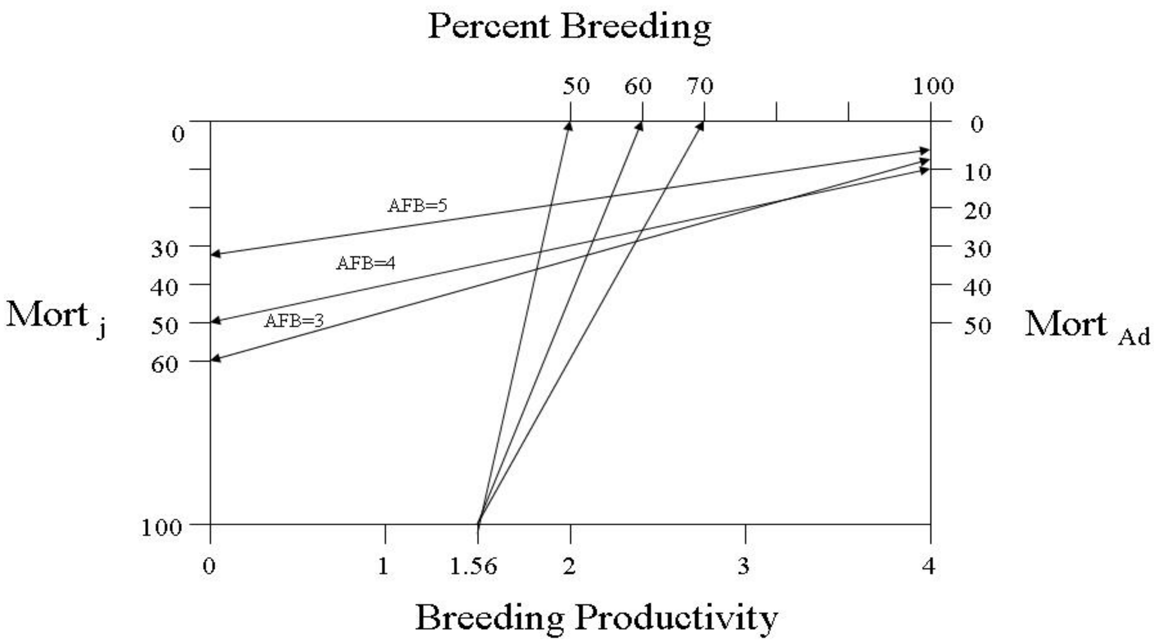


Figure 6. Range of values for selected vital parameters that would yield a positive growth rate (stochastic) for Puerto Rican parrots using the BASE model (see Appendix 3 for specifics on input values) in the YNF.

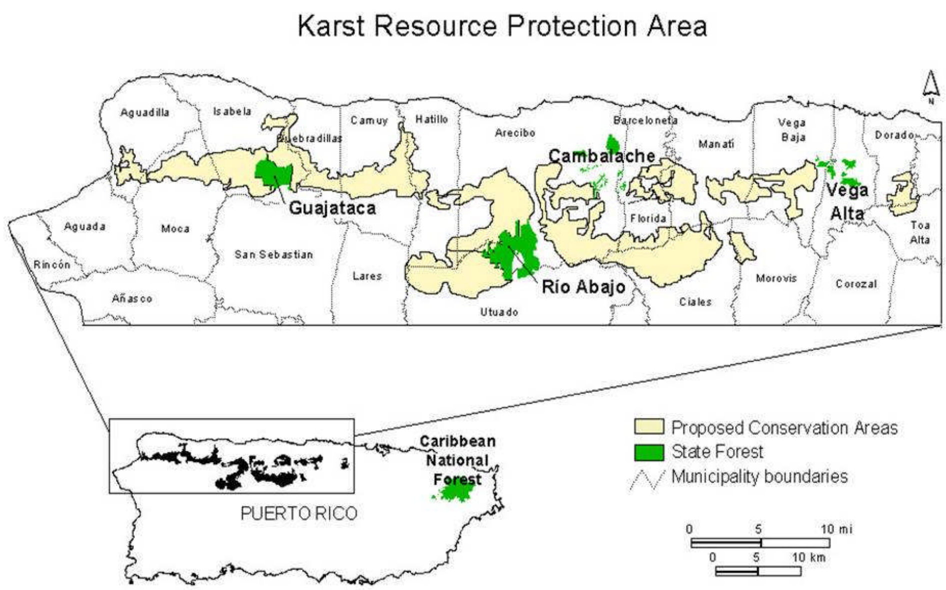
Based on our current understanding of the species' demography, the most reasonable are those encompassed (i.e., vital parameter space) among age of first breeding of 4 years (i.e., AFB = 4), proportion of breeding adults in the population of 60 percent, and the average breeding productivity of 1.56 recorded during the 1990s (Muiznieks 2003). Under those conditions, survival rates of adults and juveniles should not drop below 90 percent and 50 percent, respectively. This scenario assumes that sub-adult survival rates are around 85 percent (Snyder et al. 1987). This range of values are consistent and within the range of values emerging from the most recent demographic assessment of the species (Beissinger et al. in press). At present, available information suggests that two parameters are below those levels. Juvenile survival rates are estimated at around 0.40 where as the proportion of breeding adults in the YNF is about 0.35 (T. White, USFWS-Rio Grande Field Office, pers. comm. 2007; Beissinger et al. in press).

Information and Education: The Puerto Rican parrot and its plight continue to receive both local and national publicity in newspapers and popular magazines. A film on parrot conservation efforts (with both English and Spanish versions) was produced and promulgated some time ago. Snyder et al. (1987) published a monograph on the Puerto Rican parrot, covering the bird's natural history and conservation efforts between 1946 and 1985. An education plan has been developed and its initial phases implemented.

International recognition**:** The Rio Grande Field Office of the Service has received numerous requests for re-prints of published research and technical assistance from biologists and researchers in countries such as Cuba, Guatemala, El Salvador, Jamaica, Dominica, Bolivia, Venezuela, Perú, Argentina, Brazil, Costa Rica, Spain, France, Israel, Philippines, and New Zealand. Moreover, project personnel have recently collaborated directly on ongoing and proposed research projects on the Bahama parrot (Abaco Island Bahamas) and the endangered slender-billed parakeet in Chile.

Media efforts: The Puerto Rican parrot recovery program has also been the subject of documentaries disseminated by media outlets such as Animal Planet, British Broadcasting Corporation, World of Audubon and the radio program Earth and Sky, in addition to numerous local media outlets.

Establishment of a second wild population in the northern karst region: Forests in the north-central karst region of the island are transitional between wet (volcanic formation) and dry (limestone formation) forests (Map 3, Lugo et al. 2001). Trees species growing over these geologic formations span from representatives of the tabonuco forest in the Luquillo Mountains (80 species) to about 27 species found in dry forest (Chinea 1980).



Map 3. Map of the karst belt along the northern coastal plain of Puerto Rico. Areas in green depict the location of DNER protected areas, which are Río Abajo, Guajataca, Cambalache and Vega Alta Forest reserves. Areas in yellow represent forested tracts proposed for protection.

The RAF was identified as a site for reintroduction (USFWS 1999), primarily because it represents a protected area in and around the municipality of Utuado. Parrots outside of the Luquillo Mountains were last reported in this area in the 1930s (Wiley 1985, USFWS 1999). The forest, however, has suffered substantial alteration related to historical human activities (e.g., coffee plantations, exotic tree plantations; Departamento de Recursos Naturales 1990). As of 1983, land use in the forest was distributed as follows: 1,335 ha (3,391 acres) young secondary forest, 692 ha (1758 acres) of plantations, 855 ha (2172 acres) of dense crown forest (not deforested at least since 1936), and about 12 ha (30 acres) were deforested or were used for agriculture.

Since 1996, the DNER and the Service have sponsored research to determine the best location to reintroduce parrots and develop management strategies to foster a successful reintroduction (Collazo and Groom 2000; Appendix 7). Assessments of Río Abajo, Cambalache, and Guajataca Forest Reserves (Map 3) included selected habitat features (e.g., availability of food plant species, cavity bearing trees), as well as factors such as abundance of predators (e.g., pearly-eyed thrasher, red-tailed hawks; Muiznieck 2003, Trujillo 2005). Other studies have been designed to enhance food availability for parrots through regeneration of native species and prescribed plantings (e.g., Sierra Palm, *Prestoea montana*, Royal Palm *Roystonea borinquena*; Inman 2005). These and other data singled out the RAF as the best location to reintroduce the species in the karst region (Trujillo 2005).

Trujillo (2005) highlighted several of the strengths and habitat quality features that ranked the RAF as the best site for reintroduction. Among them is the fact that the forest receives 41 percent less precipitation than the YNF (150 cm/yr vs. 254 cm/yr). Forests in the karst region, including Río Abajo, have a lower density of red-tailed hawks ($0.23 \pm 0.05/km^2$) than the YNF ($1.56 \pm 0.25/km^2$); Frank Rivera-Milán 1995, unpubl. data, Llerandi Román 2005). Differences in hawk density could result in lower predation pressure, and hopefully, substantial gains in first year survival rates (e.g., gains of 13 percent), as hypothetical demographic scenarios suggest (White et al. 2005a). The phenology and distribution of potential food resources for parrots have been studied in the karst region of north-central Puerto Rico, including RAF (Cardona et al. 1986, Collazo and Groom 2000, Carlo et al. 2003). Historic land uses (e.g., agriculture, silviculture) in the RAF have diminished the availability of food resources in some valleys within the reserve. However, food resources abound in the upper reaches of the limestone hills and areas not used for silvicultural practices (Collazo and Groom 2000). Phenological studies by Cardona et al. (1986) suggest that peak fruit availability occurs between March and June. Their study, as well as those of Collazo and Groom (2000) and Carlo et al. (2003), suggested that food is readily available before and after this period. Many food plants are not part of the known diet of Puerto Rican parrots, but are used by Hispaniolan parrots (Collazo et al. 2000, Collazo et al. 2003, White et al. 2005c), and therefore, deemed usable by the Puerto Rican parrot. The RAF has a major advantage when compared to the other two reserves in the region. It harbors the J. L. Vivaldi Aviary, where captive birds could serve as a "surrogate" population providing a focal point where released birds could converge daily while they adjust to wild conditions.

Factors that undermine the quality of the RAF as a release site include low numbers of trees greater than 49 cm (19 in) diameter at breast height (dbh), criteria used to assess trees with cavity potential in the Luquillo Mountains (Cardona et al. 1986, Trujillo 2005). Natural crevices in the limestone landscape and artificial nest structures provided by the Service and DNER should offer suitable alternatives (USFWS 1999, White et al. 2005b). Thrasher density was highest in the RAF and surrounding forests when compared to other forest tracks in the region (Trujillo 2005). Adopting management schemes used in the YNF should minimize their potential impact on nest success. Escaped exotic avian species increase the likelihood of spreading a disease to Puerto Rican parrots. Exotic *Amazona* species pose the additional threats of interbreeding and competition. Flocks of orange-winged parrots (*Amazona amazonica*) have been seen near Manatí, a township located in the eastern portion of the karst region (Camacho et al. 2000). More recently (spring 2004), flocks of *A. ochrocephala* have been seen near the Cambalache Forest and Manatí, and three individuals of *Amazona spp.* were spotted inspecting a cavity on top of a Royal palm near the RAF in June 2004 (Trujillo 2005).

The reintroduced population in the RAF could benefit from several management activities. For example, approximately 2,720 ha (6,809 acres) of forested lands surround the forest and have been recommended for acquisition. Other avenues to protect habitat include partnerships with government and non-government organizations, and private lands initiatives (e.g., easements, Safe Harbor Agreements). The current forest management plan also includes management activities aimed at enhancing the quality of habitat for parrots (e.g., predator abatement, food availability) and providing infrastructure to monitor reintroduced birds. A joint effort among the DNER, USFS and USFWS has conducted public talks and provided written materials to the RAF adjacent communities and general public in the karst region (Appendix 7). These efforts were aimed at raising the level of public awareness about the reintroduction of parrots in the region, and fostering environmental education.

Twenty-two captive-reared parrots were released in the RAF located in the karst region of north-central Puerto Rico on November 19, 2006. This action followed an integrated recovery approached presented in Figure 7 and set in motion efforts to establish a second wild population. Lower densities of the primary avian predator of adults and juveniles, the red-tailed hawk and lower humidity may increase the likelihood of a successful establishment in this area. Long-term parrot habitat management and improvements, such as providing artificial nesting cavities in the event natural cavities are initially limiting, and proactive forest management (e.g., promoting increased food plant species and productivity) are priority recovery activities for DNER. Habitat protection and enhancement of private lands adjacent to and beyond the forest's boundaries (e.g., conservation easements, Safe Harbor Agreements) are priorities for all agencies as well.

Integrated Puerto Rican Parrot Recovery Program

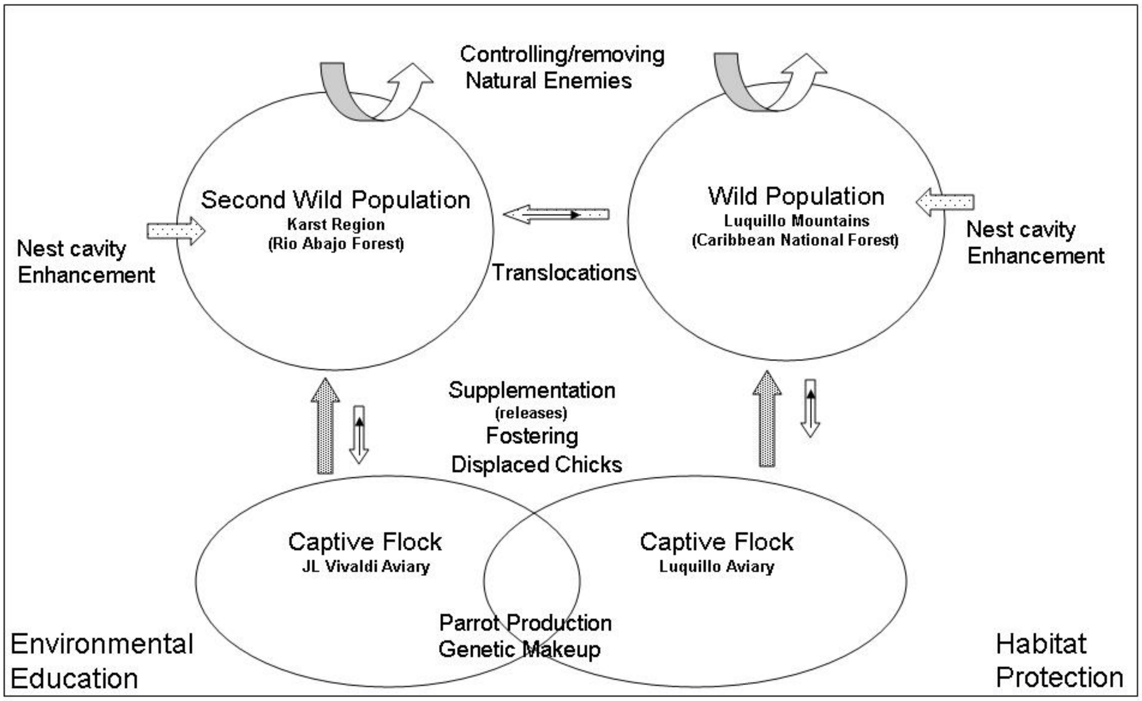


Figure 7. Puerto Rican parrot recovery program for the Luquillo Mountains and karst region.

<u>Interagency Cooperation:</u> The recovery program for the Puerto Rican Parrot is interagency effort between the USFWS, the Puerto Rico Department of Natural and Environmental Resources and the U.S. Forest Service. A Memorandum of Understanding (MOU) exists among these agencies outlining the management of the program. The MOU establishes three levels, or tiers, of collaboration: the operational level, the management level and the executive level. The Operational Committee is composed of the operational Project Leaders from each agency. The Operation Committee is responsible for the day to day operation and the implementation of the policies and directives.

The Management or Supervisory Committee is composed of the managers from each agency (the Field Supervisor for the USFWS, the Forest Supervisor for the FS and the Administrator of the DNER). This committee provides management oversight to the Operational Committee and

The Executive Committee is composed of the heads of each agency (the USFWS Regional Director, the Secretary of the DNER and the Regional Forester for the FS). The group provides policy and direction for the Program.

PART II RECOVERY

Recovery Strategy

The conservation of the Puerto Rican parrot will continue to require intensive management and targeted research. The resources required are crucial because the Puerto Rican parrot is the only extant, native psittacine in the United States, and because lessons from its recovery can and are being applied to advance the conservation of other endangered *Amazona* species in the Neotropics.

The recovery strategy for the time frame encompassed in this plan (present to 2020) has three fundamental components. The first one is to continue to implement management activities (e.g., threat abatement, captive propagation) that have prevented the extinction of the species and fostered population growth in the YNF. The second component consists of a release program capable of supporting ongoing supplementation needs in YNF and RAF, and with the long-term potential to support a reintroduction program at additional future locations. The release program is central to the recovery strategy because major strides need to be made in the near term to avoid placing all recovery prospects on a single population, hampered by admittedly sub-optimal habitat (Snyder et al. 1987, Lacy et al. 1989, Muiznieks 2003, Beissinger et al. in press). The program represents a mechanism to bolster the wild population while allowing for the reintroduction of the species in other suitable habitats such as the reintroduction of the species in the RAF in November 2006 (Collazo et al. 2003, Trujillo 2005, White et al. 2005a). Multiple, interacting populations, are essential to achieve full recovery and viability (Lacy et al. 1989). A successful reintroduction in the karst region (RAF), coupled with habitat protection, will facilitate the eventual establishment of a third population.

Owing to the small size of the wild population, translocation of adult wild birds to reintroduction sites is not advisable in the foreseeable future (Collazo et al. 2000, Beissinger et al. in press). Using conservative vital parameter values Collazo et al. (2000) suggested that “harvesting from the wild population” in the YNF for translocations would not be possible until the wild population size exceeded 125 individuals. For the foreseeable future, any reintroduction effort will depend on captive-reared birds.

The final component of the recovery strategy is a program review process to set recovery milestones and target dates to review accomplishments, and implement revised recovery actions. The latter would stem from evaluations of the demography of, and recovery outlook for, the species. The first of these reviews is scheduled for 2011. Recovery actions, milestones and dates for a review of accomplishments are outlined below.

Recovery Objective and Criteria

The objective of this recovery plan is to downlist, and then delist the Puerto Rican parrot, ensuring its persistence and long-term viability in the wild. A viable population is a reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. The number of individuals needed and the amount and quality of habitat required to meet these criteria will be determined for the species as one of the recovery tasks, and adjusted periodically during review of program accomplishments (i.e., milestones). Recovery criteria proposed herein are designed to serve as guidelines to set the recovery program on a path towards downlisting. They are based on the minimum values of selected vital parameters that promote population growth (positive stochastic growth rate) based on our current understanding of the species' demography.

Downlisting the Puerto Rican parrot from endangered to threatened will be considered when:

1. A wild population in the Luquillo Mountains exists with a population size (yet to be determined) that exhibits vital parameters consistent with a trajectory towards maintenance. At present, population growth in the YNF could be expected if the breeding productivity is at least 1.56 chicks per nesting attempt (average rate for the 1990s) and their survival rates should not drop below 90 percent for adults and 50 percent for juveniles. These rates assume that sub-adult survival rates are around 85 percent, age of first breeding is four years old, and at least 60 percent of the adults engage in reproduction each year (Figure 6). A higher number of breeding pairs is essential for vigorous population growth and historically has been stagnant at 2-6 pairs.
2. A second wild population in the northwestern karst region exists with a population size (yet to be determined) that exhibits vital parameters consistent with a trajectory towards maintenance.
3. The reintroduction or creation of at least a third population has been achieved in a suitable forested area in the island reflecting lessons and demographic expectations stemming from work with wild populations and release programs in RAF and YNF.
4. Nesting and foraging habitats (yet to be determined) are protected to support growing populations.

<u>Delisting</u>

The Puerto Rican parrot will be considered for delisting when:

1) At least three interacting populations exist in the wild and population growth is sustained for 10 years after downlisting has occurred. This length of time will allow monitoring four recruitment events and other population attributes in a species that has been characterized by highly variable reproductive and survival rates, at least in the YNF (Snyder et al. 1987, Muiznieks 2003, Beissinger et al. in press). Reviews of the recovery program prior to making a delisting determination will help define more explicitly the range of vital parameter values of a recovered population (see milestones 2 and 3).
2) Long term protection of the habitat occupied by each wild population is achieved.
3) The effects of disease and predation factors are controlled to allow for population viability.

Progress towards downlisting and ultimately recovery will be reviewed on a timetable defined by recovery milestones. Milestones will trigger a review of accomplishments and incorporation of adjustments to the recovery program. The period of review in the short-term will be from 2008 to 2011, four milestones are proposed (refer to Recovery Milestones below). The milestones are set within the timeframe encompassed by the full implementation of the reintroduction program in the karst region, which started in 2006 and scheduled to last 5 years. A Population Viability Analysis for the YNF population is scheduled for 2008, or three years after the most recent analysis (Beissinger et al. in press), and again in 2011, to conduct a comprehensive evaluation of the status of the two wild populations (i.e., El Yunque and Río Abajo Forests). In 2011, adjustments to the recovery program, including setting new milestones, contained in a revised recovery plan will lead recovery efforts to meet the species' downlisting recovery criteria in 2020.

Recovery Milestones:

1. The Genetic Management Plan for the Iguaca and J. L. Vivaldi Aviaries and wild chicks from YNF was implemented in 2005. Review aviary accomplishments in 2008 and 2011 and revise aviary protocols accordingly. Review effectiveness and use (e.g., pairings, candidates for release) of Genetic Management Plan as a recovery tool.
2. Reintroduction of Puerto Rican parrots in the RAF began in 2006. Conduct demographic analyses and review of the reintroduction program in 2011.
3. Conduct PVA for the YNF population in 2008 and 2011, and evaluate effectiveness of release program.
4. Complete evaluation and selection of prospective reintroduction sites for a third wild population by 2011, and develop and implement plans to sustain new release program.
5. Review and update the Recovery Plan in 2013 as new information is gained to include updated actions, costs, and criteria for delisting.

Table 5. Relationship of Recovery Criteria and Threats for *Amazona vittata*.

THREAT	RECOVERY CRITERIA A	B	RECOVERY ACTIONS
The present threatened destruction , modification , or curtailment of it habitat or range	1,2,3,4	1,2	**117** Minimize losses to humans and human activities, **118** Minimize threats from exotic psittacines, **21** Delineate occupied range, and assess habitat use, **22** Explore means to protect , improve, and acquire habitat outside, but adjacent, to the YNF and RAF, **23** Provide technical assistance and support to landowners to protect and manage their property for the benefit of the Puerto Rican parrots, **41** Continue release of captive-reared Puerto Rican parrots to promote growth of the wild population in the YNC using procedures developed to maximize survival, **42** Continue release of captive-reared parrots to establish a second wild population in RAF, **44** Provide and maintain nest structures to foster successful reproduction in RAF, **52** Implement expanded release program, **61** Maintain a proactive public outreach program
Overutilization for commercial , recreational scientific, or educational purposes	N/A	N/A	N/A
Disease or predation	1,2,3,4,	4	**111** Minimize losses to Pearly-eyed Thrashers, **112** Minimize warble fly parasitism, **113**, Minimize losses to rats, **114** Minimize losses to honeybees, **115** Minimize losses to raptors, **116** Minimize losses to other predators, **118** Minimize threats from exotics psittacines, **32** Maintain captive stock in good health, **33** Conserve genetic variation of captive and wild flocks, **43** Monitor all releases of Puerto Rican Parrots to identify mortality factors and to reduce their impacts.
Inadequacy of Existing Regulatory Mechanisms		3	**63** Enforce existing laws
Other Natural or manmade factors affecting its continued existence	1,2,3,4,	1,2,3,4	**117** Minimize losses to humans and human activities, **118** Minimize threats from exotic psittacines, **21** Delineate occupied range, and assess habitat use, **22** Explore means to protect , improve, and acquire habitat outside, but adjacent, to the YNF and RAF, **23** Provide technical assistance and support to landowners to protect and manage their property for the benefit of the Puerto Rican parrots, **41** Continue release of captive-reared Puerto Rican parrots to promote growth of the wild population in the YNC using procedures developed to maximize survival, , **42** Continue release of captive-reared parrots to establish a second wild population in RAF, , **44** Provide and maintain nest structures to foster successful reproduction in RAF, **52** Implement expanded release program **61** Maintain a proactive public outreach program

Listing Factors:

- A. The Present or Threatened Destruction, Modification, or Curtailment of a Species Habitat or Range
- B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes
- C. Disease or Predation
- D. Inadequacy of Existing Regulatory Mechanisms
- E. Other Natural or Manmade Factors Affecting its Continued Existence

Recovery Criteria for Downlisting (A):

1. A wild population in the Luquillo Mountains exists with a population size (yet to be determined) that exhibits vital parameters consistent with a trajectory towards maintenance. At present, population growth in the YNF could be expected if the breeding productivity is at least 1.56 chicks per nesting attempt, and their survival rates should not drop below 90% for adults and 50% for juveniles;
2. A second wild population in the northwestern karst region with population size (yet to be determined) that exhibits vital parameters consistent with a trajectory towards maintenance.
3. The reintroduction or creation of at least a third population in a suitable forested area in the island reflecting lessons and demographic expectations stemming from work with wild populations and release programs in RAF and YNF.
4. Nesting and foraging habitats (yet to be determined) are protected to support growing populations.

Recovery Criteria for Delisting (B):

1. At least three interacting populations exist in the wild and population growth is sustained for 10 years after downlisting has occurred. The length of time will allow monitoring 4 recruitment events and other population attributes in a species that has been characterized by highly variable reproductive and survival rates (Snyder et al. 1987, Muiznieks 2003, Beissinger et al. in press). Reviews of the recovery program prior to making a delisting determination will help define more explicitly the range of vital parameter values of a recovered population (see milestones 2 and 3).
2. Long term protection of the habitat occupied by each wild population is achieved,
3. The effects of disease and predation factors are controlled to allow for population viability.

Actions Needed:

1. **Protect and manage the Puerto Rican parrot wild population**.
2. **Assess and protect current and future public and privately-owned habitat for the Puerto Rican parrot.**
3. **Maintain and manage the captive flocks.**
4. **Release captive produced parrots to augment the wild population and establish additional wild populations.**
5. **Establish a third wild population.**
6. **Continue public awareness and education programs, and enforce existing laws to promote support for the recovery program.**
7. **Refine recovery criteria**

Recovery Action Outline

1. Protect and manage the Puerto Rican parrot wild population.
   - 1.1. Protect and manage wild nests and their habitat, and implement mechanisms to reduce loss of parrot eggs, nestlings, fledglings, and adults from enemies
     - 1.1.1. Minimize losses to pearly-eyed thrashers
     - 1.1.2. Minimize warble fly parasitism
     - 1.1.3. Minimize losses to rats.
     - 1.1.4. Minimize losses to honeybees.
     - 1.1.5. Minimize losses to raptors.
     - 1.1.6. Minimize losses to other predators.
     - 1.1.7 Minimize losses to humans and human activities.
     - 1.1.8. Minimize threat from exotic psittacines.
   - 1.2. Maximize parrot reproduction in the wild.
   - 1.3. Foster captive-produced chicks into wild parrot nests.
   - 1.4. Monitor wild population size.

2. Assess and protect current and future public and privately-owned habitat for the Puerto Rican parrot.
   - 2.1. Delineate occupied range, and assess habitat use.
   - 2.2. Explore means to protect, improve, and acquire habitat outside, but adjacent to, the YNF and the RAF.
   - 2.3. Provide technical assistance and support to landowners to manage their property for the benefit of Puerto Rican parrots.

3. Maintain and manage the captive flocks.
   - 3.1. Maximize production of Puerto Rican parrots in captive.
   - 3.2. Maintain captive stock in good health.
   - 3.3. Conserve genetic variation of captive and wild flocks.

4. Release captive produced parrots to augment the wild population and establish additional wild populations.
   - 4.1. Continue release of captive-reared parrots to promote growth of the wild population in the YNF using procedures developed to maximize survival.
   - 4.2. Continue release of captive-reared parrots to establish a second wild population in RAF.
   - 4.3. Monitor all releases of Puerto Rican parrots to identify mortality factors and to reduce their impacts.
   - 4.4. Provide and maintain nest structures to foster successful reproduction in RAF.

5. Establish additional wild populations.
   - 5.1. Develop plans to expand the release program.
   - 5.2. Implement expanded release program.

6. Continue public awareness and education program, and enforce existing laws to promote support for the recovery program.
    6.1. Maintain a proactive public outreach program.
    6.2. Incorporate information about the parrot recovery program into the existing DNER hunter education safety course.
    6.3. Enforce existing laws.

7. Refine recovery criteria.
    7.1. Determine number of individuals and populations necessary to ensure species persistence.
    7.2. Determine the amount of habitat required by parrots to insure its persistence.
    7.3. Determine what additional actions, if any, are required to achieve recovery criteria.

Recovery Action Narrative

1. **Protect and manage the Puerto Rican parrot wild population**. The major mechanisms to achieve this action are: 1) increasing the number of individuals by enhancing reproduction, fostering chicks into wild nests, and releasing captive raised birds; and 2) minimizing threats to the species and its habitat through nest guarding, control of predators and competitors, conducting habitat manipulations, and protecting essential habitat.

1.1. Protect and manage wild nests and their habitat, and implement mechanisms to reduce loss of parrot eggs, nestlings, fledglings, and adults from enemies. Nests used by the Puerto Rican parrot must be managed intensively to ensure their suitability and availability during the nest selection and breeding seasons. Currently, effective practices exist and are being used to maintain and improve cavity conditions. Nest monitoring from observation blinds by field personnel has been an integral part of the recovery efforts in YNF and will constitute an important component of the management of any future reintroduced population. In YNF, two recent improvements are currently contributing to an increase in wild nest success, namely, the provision of improved natural or artificial nest sites and refinement of nest guarding techniques using cameras, which have been placed to aid the monitoring of nesting activities, detect potential problems, and assess the condition of developing chicks to prevent deaths from disease or parasites. These practices will continue as long as positive results are obtained.

1.1.1. Minimize losses to pearly-eyed thrashers. Two management tools are used and will continue being used to address this action. The first consists of parrot nest modifications and the second of placing 2 to 3 thrasher nest boxes near parrot nests. If parrot nest destruction or takeover by thrashers appears imminent, then intervention or artificial incubation of parrot eggs is initiated.

1.1.2. Minimize warble fly parasitism. Previous installation of listening devices, followed by installation of cameras in each nest beginning in 2004 have greatly improved the rate of warble fly detection, although chicks are visually checked every 5-7 days. To prevent infestation, nest materials are kept as dry as possible and treated with carbaryl insecticide (e.g., Sevin)

1.1.3. Minimize losses to rats. This task is addressed by setting multiple traps per active nest, and placing palletized rat bait (e.g., anticoagulant) before nest selection (about December), followed by additional applications once a month until fledgling.

1.1.4. Minimize losses to honeybees. Protocols for bee interception and eradication have been developed and implemented to protect parrots from this nest competitor. Primary measures include swarm trapping during the summer (when most swarming takes place), removal of hives during the non-breeding season from traditional or potential parrot nests, and temporary closure of nest entrances. Nests and alternative cavities must remain closed outside of the nesting season to discourage their deterioration and occupation by enemies or competing species. They must be opened and serviced promptly just before the nest selection period, be actively maintained throughout the breeding season, and closed soon after fledgling. Implementation of bee management protocols will continue.

1.1.5. Minimize losses to raptors. Red-tailed hawks are selectively removed from traditional nesting/use areas in YNF. As part of this management practice, regular monitoring of the raptor population in the target areas is conducted to compare with pre-removal estimates, and the survival of the parrot fledglings are monitored using telemetry. The need for similar measures in the karst region, specifically RAF, should be evaluated.

1.1.6. Minimize losses to other predators. The potential influence that other types of predators (e.g., boas, feral cats) could have on parrots, particularly nesting success, continues to be assessed in YNF, and is currently being assessed in RAF.

1.1.7. Minimize losses to humans and human activities. All research and management activities proposed within the influence zone of occupied parrot habitats (1 km radius from core nesting area) within YNF and RAF should be reviewed by field personnel to evaluate potential effects on the parrot and its habitat and to provide site-specific conservation measures to reduce any potential for human disturbance. To minimize potential incidental deaths of parrots, especially during the pigeon-hunting season, YNF and RAF and their buffer zones should be maintained as no shooting areas.

1.1.8. Minimize threats from exotic species, especially exotic psittacines. Introduced psittacine species are reproducing in the lowlands of Puerto Rico. At present, they are not known to affect the Puerto Rican parrot in the YNF, although sporadic observations of exotic psittacines have occurred within YNF. *Amazona spp*. have also been reported within the RAF and other areas of the karst region. Adequate monitoring of exotic species reproducing in the wild should occur. If exotic psittacines become a threat to the recovery of the parrot, control techniques should be developed and implemented. These could include trapping, shooting, and actively displacing exotic birds, or habitat modifications.

1.2. Maximize parrot reproduction in the wild. Further increases in breeding productivity in YNF may be attained by increasing the number of breeding pairs and enticing parrots to establish new, multiple nesting areas. Meeting this goal is essential to break the demographic inertia that has characterized the wild population in YNF. To foster additional pairs, a better understanding of the mechanisms involved in nest selection and fidelity is required. Peer-reviewed scientific studies have expanded our understanding of this process, providing criteria which will be used to guide future placement of artificial nest structures. Clutch manipulations, mainly double clutching, have also been conducted with some success in the past and will be used in the future in selected circumstances.

1.3. Foster captive-produced chicks into wild parrot nests. Fostering has been an effective and practical way to increase breeding productivity, and a means to introduce chicks produced in captivity into the wild. Sustained high breeding productivity levels are needed (greater than or equal to 1.56 chicks per nest attempt) to promote consistent population growth, particularly if new breeding pairs are recruited into the population. Wild population management will continue to employ this practice when applicable.

1.4. Monitor wild population size. This parameter is estimated by conducting pre- and post-breeding counts in parrot activity areas (e.g., nesting areas) by multiple trained observers. Each count consists of 3-4 events, conducted during mornings and evenings of consecutive days, and a minimum or conservative count taken as the best estimate of the population. Detection and spatial sampling biases will be assessed periodically by taking advantage of instrumented birds, and by scouting portions of YNF for the presence of parrots prior to surveys. As populations increase in size and spatial distribution, sampling protocols will be adjusted in consultation with population estimation experts. Similar methods should also be developed and implemented for the RAF population.

2. Assess and protect current and future public and privately-owned habitat for the Puerto Rican parrot. Continued monitoring of parrots within occupied areas and adjacent lands is vital to identify and delineate specific parrot habitats, both current and potential. The identification of specific use areas (such as breeding, feeding, and movement areas) and their characteristics provide information needed to better understand parrot-habitat relationships, and define management needs and opportunities.

Both currently known parrot populations are located within public forests managed for conservation. Existing management plans provide direction for long-term parrot habitat protection, management and enhancement and place high emphasis on Puerto Rican parrot recovery. Every effort should be made by the Federal and Commonwealth governmental agencies to encourage the protection of privately-owned lands adjacent to these protected areas, particularly in the karst region to increase availability of protected suitable habitat for the parrot. Existing conservation programs for private landowners should be coordinated and focused in areas adjacent to parrot populations.

2.1. Delineate occupied range, and assess habitat use. Information on parrot use-areas and dispersal will be acquired through continued monitoring using periodic population counts and surveillance of parrot activities, especially with the aid of radio telemetry. Released and wild parrots will be monitored to identify occupied range and determine if management is required to meet their habitat requirements or abate limiting factors (e.g., nest predators). As the population increases in numbers, the area occupied by parrots is expected to expand. It is critical that their future range be monitored to adjust the recovery program accordingly, including the need to protect areas outside YNF and RAF.

2.2. Explore means to protect, improve, and acquire habitat outside, but adjacent to, the YNF and the RAF. Parrots sometimes use areas outside of YNF and RAF. These lands may eventually be important to parrot recovery. Federal and Commonwealth agencies and non-governmental organizations should pursue every opportunity to acquire such lands or to develop other conservation mechanisms, such as conservation easements, zoning regulations or voluntary cooperation.

2.3. Provide technical assistance and support to landowners to protect and manage their property for the benefit of Puerto Rican parrots. Landowner incentive programs, such as Partners for Fish and Wildlife, Coastal Program, Safe Harbor Agreements, Private Stewardship Grants, and the Farm Bill can provide technical assistance and incentives to apply the best management practices, through site visits, local recognition, and development of habitat conservation plans. Interagency cooperation should continue identifying and implementing an array of programs aimed at the conservation of forested areas.

3. Maintain and manage the captive flocks.

3.1. Maximize production of Puerto Rican parrots in captivity. A minimum of 32 breeding Puerto Rican parrot pairs are currently housed at the Iguaca and J. L. Vivaldi Aviaries, with additional surrogate Hispaniolan parrot pairs to aid management. Opportunities and means to increase captive production are given priority in both aviaries. Examples include experimental pairings of adults, transfers between aviaries, cage and nest designs, and relocations of captive pairs within the aviaries. New mates should be provided to females laying infertile eggs to promote compatible (i.e., fertile egg-producing) pairs. The possibility of increasing production by double clutching and foster rearing should be given consideration when appropriate. Hand rearing of parrot chicks should be considered as a last option when no other alternatives exist.

Numerous protocols exist regarding specific subject areas, such as daily sanitation, egg fertility/hatchability, hand feeding, seasonal physical examinations, fostering chicks into wild nests, produce and maintain birds for release and habitat enrichment.

3.2. Maintain captive stock in good health. Both aviaries should continue maintaining staff trained and experienced in bird health problems. At both aviaries, a qualified veterinarian performs periodic exams on a selected number of captive parrot representatives of each of the captive flocks, in addition to responding to any emergency veterinary needs. Interagency efforts should continue to maintain funding for veterinary services and close coordination between both facilities.

3.3. Conserve genetic variation of captive and wild flocks. A critical step in genetic and demographic management of Puerto Rican parrots is to have the single population animal record keeping software (SPARKS) pedigree/demography dataset kept up to date at all times with information from both aviaries and the wild. Recommendations for breeding specific individuals to conserve genetic variation should be conducted annually and are generally based on mean kinship and founder contributions calculated from the Puerto Rican parrot SPARKS database. Such a breeding program will result in retention of maximum genetic variation in the captive population. Recovery actions that minimize inbreeding potential should be evaluated jointly, under the auspices of the Genetic Management Plan, to develop a coordinated approach to deal with this challenge. Additionally, the pedigree is managed with birds from both aviaries and the wild combined in one database, thus multiple analyses (wild vs. captive) may be needed prior to implementing breeding and/or translocation plans.

4. **Release captive produced parrots to augment the wild population and establish additional wild populations.** Protocols to carry out the releases and methods to determine their success (e.g., survival) have been developed and continually refined through multiple releases over time. This conservation approach is vital to promote population persistence of the existing wild population and to establish additional wild populations.

4.1. Continue release of captive-reared parrots to promote growth of the wild population in the YNF using procedures developed to maximize survival. Releases must continue (e.g., 2-3 consecutive years at a time), followed by a careful evaluation of their demographic impact. Adjustments to the program should be incorporated as needed, applying concepts of adaptive management.

4.2. Continue release of captive-reared parrots to establish a second wild population in RAF. Parrots were initially released in RAF in November 2006. Initial management activities consisted of nest augmentation, pest abatement, and placement of a preliminary monitoring infrastructure. Protection and further enhancement of the flocks in an integrated fashion will follow (Figure 7). The experience and participation of all cooperators presently involved in the recovery program will be essential for the successful establishment of the second wild population.

4.3. **Monitor all releases of Puerto Rican parrots to identify mortality factors and to reduce their impacts.** All captive-reared parrots are marked to enable individual identification after release. In addition to a metal leg band, birds are fitted with radio-transmitters. Birds are tracked for up to a year to determine their fate (e.g., survival) and use of habitat. From this same body of data, mortality factors are identified and measures to curb their impact implemented (e.g., predator control).

4.4. Provide and maintain nest structures to foster successful reproduction in RAF. Although potential nesting sites may exist in the form of dead, scattered royal palms, older growth forest in sinkholes, and cavities in limestone cliffs, placement of artificial nest structures throughout the release area will be, as in the YNF, essential for establishment and maintenance of a resident breeding population. Artificial cavities will follow the design used in YNF, and placement will follow criteria identified in peer-reviewed scientific research. Any existing natural cavities encountered within the 1.5 km radius should also be inspected and enlarged or otherwise improved as necessary.

5. **Establish additional wild populations as defined in the criteria.** Multiple, and preferably, interacting populations minimize the likelihood of extinction and are demographic attributes associated with a viable species, the goal of this recovery plan for the parrot. An expanded release program represents a powerful recovery tool to make major strides towards that goal.

5.1. Develop plans to expand the release program. An expanded release program will require: 1) increased aviary production under a coordinated genetic framework, 2) candidate locations for reintroductions, and 3) capabilities to implement management activities to deal with threats encountered by released parrots. The planning process will be completed by 2011, following procedures outlined in tasks 4.1 and 4.3.

5.2. Implement expanded release program. The timetable and procedures for these releases will be determined during the review process scheduled for 2011.

6. **Continue public awareness and education programs, and enforce existing laws to promote support for the recovery program.** The future of the parrot ultimately depends on the will and participation of people in the protection and conservation of the species and its habitat. Therefore, conveying accurate information on the plight of the species, the factors leading to its endangerment, and the importance of protecting the Puerto Rican parrot to the general public is essential for its recovery. Likewise, laws and regulations that afford protection and support to the recovery program should be enforced.

6.1. Maintain a proactive public outreach program. A public outreach plan has been developed that provides awareness of the importance to protect and conserve the endangered parrot. The plan was implemented for the efforts related to the release of parrots in the karst region. The materials developed for the implementation of the plan are available and should be used in anticipation of future release events.

6.2 Incorporate information about the parrot recovery program into the existing DNER hunter education safety course. Outreach should also be conducted with organized hunter's organizations to promote knowledge of the conservation needs of the parrot and promote compliance with applicable statutes and regulations.

6.3. Enforce existing laws. Enforce provisions under the Endangered Species Act (as amended), and the Commonwealth Wildlife Law 241 of 1999, the Regulation to govern vulnerable and endangered species, and the Regulation to govern the wildlife species, exotic species and hunting in the Commonwealth of Puerto Rico. Protection of parrots from human activities also includes monitoring parrot exportation from Puerto Rico (pet trade), and controlling or prohibiting the importation of exotic avian species (e.g., *Amazona* species) to minimize the potential for competition, hybridization, and epizootics. If importation is allowed, each application should go through a review by DNER. Further introductions or escapes into the wild of exotic psittacine and other species must be prevented.

7. **Refine recovery criteria.** As new and additional information on the biology, ecology, and management of the Puerto Rican parrot becomes available, it might be necessary to reevaluate and redefine recovery criteria.

   7.1. Determine number of individuals and populations necessary to insure species' persistence. Population studies and monitoring, together with the relative success of protection measures, will help in the estimation of more precise vital parameters, including size of the population. Program monitoring will include measuring progress towards retaining genetic diversity. These data will be summarized and used to conduct PVAs and other demographic modeling tools in years 2008 and 2011 (YNF) and in 2011 (RAF) to establish revised, attainable milestones and refine relevant recovery criteria.

   7.2. Determine the amount of habitat required by parrots to insure its persistence. Wild and captive reared parrots will be monitored to identify and delineate occupied range and habitat requirements. Monitoring will be accomplished using radio-telemetry, periodic population counts, and surveillance from observation platforms or posts. As populations increase in numbers, the areas occupied by parrots are expected to increase. It is critical that their range be monitored to adjust the recovery program habitat protection measures and strategies accordingly. Habitat protection strategies should account for episodic events, such as hurricanes when parrots may more than double their habitat requirements in the aftermath of the storm.

   7.3. Determine what additional actions, if any, are required to achieve recovery criteria. Program reviews triggered by task 7.1. and 7.2. will be used to make the necessary adjustments to the recovery programs to promote population growth, and ultimately, species viability. These measures will be incorporated in future revisions to the recovery plan.

Implementation Schedule

Recovery plans are intended to assist the Service and potential Federal, state, and private partners in planning and implementing actions to recover and/or protect endangered and threatened species. The Implementation Schedule that follows lists the actions and estimated costs for the recovery program for *Amazona vittata*. It is a guide for meeting recovery goals outlined in this plan. Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule. The listing of a party in the Implementation Schedule does not require, nor imply a requirement, that the identified party has agreed to implement the action(s) or to secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover *Amazona vittata*. Also, section 7(a)(1) of the ESA directs all Federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species.

Recovery Action Priorities

Priorities in column 1 of the following Implementation Schedule are assigned as follows:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

List of Abbreviations

YNF	El Yunque National Forest
RAF	Rio Abajo Forest
USFWS	U.S Fish and Wildlife Service
DNER	Puerto Rico Department of Natural and Environmental Resources
USFS	U.S. Forest Service
PVA	Population Viability Analysis
BASE	Basic Scenario
MOU	Memorandum of Understanding
RGFO	Rio Grande Field Office

IMPLEMENTATION SCHEDULE

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Annual Fiscal-Year Cost Estimate In Thousands of Dollars ($000) 1	2	3	4	5	6	7	8	9	10
1	Minimize losses to pearly-eyed thrashers.	1.1.1.	ongoing	ES	USFS	2	2	2	2	2	3	3	3	3	3
1	Minimize warble fly parasitism.	1.1.2.	ongoing	ES	USFS	2	2	2	2	2	3	3	3	3	3
1	Minimize losses to rats.	1.1.3.	ongoing	ES	USFS	2	2	2	2	2	3	3	3	3	3
1	Minimize losses to honeybees.	1.1.4.	ongoing	ES	USFS	2	2	2	2	2	3	3	3	3	3
1	Minimize losses to raptors.	1.1.5.	ongoing	ES	USFS	2	2	2	2	2	3	3	3	3	3
1	Minimize losses to other predator.	1.1.6.	ongoing	ES	DNER, USFS	2	2	2	2	2	3	3	3	3	3
1	Minimize losses to humans and human activities.	1.1.7.	ongoing	ES	DNER, USFS	12	12	13	13	14	14	15	15	16	16
1	Minimize threat from exotic species, especially exotic psittacines.	1.1.8.	ongoing	ES	DNER	10	10	10	12	12	12	14	14	14	16
1	Maximize parrot reproduction in the wild.	1.2.	ongoing	ES	DNER	65	67	69	71	73	75	77	79	81	83
1	Foster captive-produced chicks into wild parrot nests.	1.3.	ongoing	ES	DNER	Cost included in task 1.2.									
1	Monitor wild population size.	1.4.	ongoing	ES	DNER, USFS	20	20	22	22	24	24	26	26	28	28
1	Maximize production of Puerto Rican parrots in captive.	3.1.	ongoing	ES	DNER	600	610	620	630	640	650	660	670	680	690
1	Maintain captive stock in good health.	3.2.	ongoing	ES	DNER	Cost included in task 3.1.									

Implementation Schedule (continued)

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization FWS	Other	Annual Fiscal-Year Cost Estimate In Thousands of Dollars ($000) 1	2	3	4	5	6	7	8	9	10
1	Continue release of captive-reared Puerto Rican parrots to promote growth of the wild population in the YNF using procedures developed to maximize survival.	4.1.	ongoing	ES	DNER, USFS			35		40		45		50	
1	Continue release of captive-reared parrots to establish a second wild population in RAF.	4.2.	ongoing	ES	DNER	225	225	230	230	235	235	240	240	245	245
1	Monitor all releases of Puerto Rican parrots to identify mortality factors and to reduce their impacts.	4.3.	ongoing	ES	DNER	Cost included in tasks 4.1 and 4.2.									
1	Enforce existing laws.	6.3.	ongoing	ES, LE	DNER, USFS	2	2	3	3	3	4	4	4	4	4
2	Explore means to protect improve, and acquire habitat outside, but adjacent to the YNF and the RAF	2.2.	continual	ES	DNER, USFS	Variable									
2	Conserve genetic variation of captive and wild flocks.	3.3.	ongoing	ES	DNER	3	3	3	3	3	4	4	4	4	4
2	Provide and maintain nest structures to foster successful reproduction in RAF.	4.4.	continual	ES	DNER, USFS	12	5	4	3	2	2	2	2	2	2
2	Implement expanded release program.	5.2.		ES	DNER				60	65	70				

Implementation Schedule (continued)

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization FWS	Responsible Organization Other	Annual Fiscal-Year Cost Estimate In Thousands of Dollars ($000) 1	2	3	4	5	6	7	8	9	10
2	Determine number of individuals and populations necessary to ensure species persistence.	7.1.	2 years	ES	DNER, USFS				12			15			
2	Determine the amount of habitat required by parrots to insure its persistence.	7.2.		ES	DNER, USFS	Cost included in task 4.1. and 4.2									
2	Determine what additional actions, if any, are required to achieve recovery criteria.	7.3.		ES	DNER, USFS	Cost included in task 4.1. and 4.2									
3	Delineate occupied range, and assess habitat use.	2.1.	ongoing	ES	DNER, USFS	30	30	32	32	34	34	36	36	38	38
3	Provide technical assistance and support to landowners to protect and manage their property for the benefit of Puerto Rican parrots.	2.3.	continual	ES	DNER, USFS	Cost included in task 62									
3	Develop plans to expand the release program.	5.1.	2 years	ES	DNER	2	4								
3	Maintain a proactive public outreach program.	6.1.	ongoing	ES	DNER, USFS	1	1	1	1	1	1	1	1	1	1
3	Incorporate information about the parrot recovery program into the existing DNER hunter education safety course.	6.2.		ES	DNER	2		1		1		1		1	

Literature Cited

Arendt, W. J. 1985. *Philornis* ectoparasitism of Pearly-eyed Thrashers. I. Impact on growth and development of nestlings. Auk 102:270-280.

Arendt, W. J. 2000. Impact of nest predators, competitors, and ectoparasites on Pearly-Eyed Thrashers, with comments on the potential implications for Puerto Rican Parrot recovery. Ornitologia Neotropical. 11:13-63.

Ballou, J. D., and R. C. Lacy. 1995. Identifying genetically important individuals for management of genetic variation in pedigreed populations. Pp. 76-123 *in* J. D. Ballou, M. Gilpin, and T. J. Foose, eds. Population management for survival and recovery. Columbia University Press, NY, NY.

Ballou, J. D., and T. J. Foose. 1996. Demographic and genetic management of captive populations. Pp. 263-283 in D. G. Kleiman, M. E. Allen, K. V. Thompson, and S. Lumpkin, eds. Wild Mammals in Captivity: Principles and Techniques. University of Chicago Press, Chicago, IL.

Beissinger, S. R., J. M. Wunderle, Jr., J. M. Meyers, B-E. Saether, and S. Engen. In Press. Anatomy of a bottleneck: diagnosing factors limiting population growth in the Puerto Rican Parrot. Ecological Monographs.

Birdsey R. A. and P. L. Weaver. 1982. The forest resource of Puerto Rico. USDA Forest Service Resource Bulletin, SO-85. New Orleans, LA, Southern Forest Experiment Station. 59 pp.

Brock, M. K., and B. N. White. 1992. Application of DNA fingerprinting to the recovery program of the endangered Puerto Rican parrot. Proc. Natl. Acad. Sci. 89:11121-11125.

Camacho Rodriguez, M.; J. L.Chabert Llompart and M. López Flores. 2000. Guía para Identificación de las Aves Exóticas Establecidas en Puerto Rico. Departamento de Recursos Naturales y Ambientales de Puerto Rico. 53pp.

Cardona, J. E., M. Rivera, M. Vázquez-Otero, C. R. Laboy. 1986. Availability of food resources for the Puerto Rican parrot and the Puerto Rican plain pigeon in Río Abajo Forest. Puerto Rico Department of Natural Resources, Draft Report Project No. W-10 (ES-1).

Carlo, T. A., J. A. Collazo and M. J. Groom. 2003. Avian fruit preference and seed dispersal effectiveness: A view of landscape variation of bird-plant interactions. Oecologia 134:119-131.

Caughley, G. C. 1977. Analysis of Vertebrate Populations. Wiley, New York, New York, USA.

Chinea, J. D. 1980. The forest vegetation of the limestone hills of northern Puerto Rico. M.S. thesis, Cornell University, Ithaca, New York, USA. __pp.

Christian, C. S., T. E. Lacher, Jr., M. P. Zamore, T. D. Potts, and W. Burnett. 1996. Parrot conservation in the Lesser Antilles with some comparison to the Puerto Rican efforts. Biological Conservation 77:159-167.

Collazo, J. A. and M. J. Groom. 2000. Avian conservation in north-central forested habitats in Puerto Rico. Final report, Puerto Rico Dept. of Natural and Environmental Resources, Federal Aid Project W-20, San Juan, PR. 245 pp.

Collazo, J. A., F. J. Vilella, T. H. White, and S. Guerrero. 2000. Survival, use of habitat, and movement of captive-reared Hispaniolan parrots released in historical, occupied habitat: implications for the recovery of the Puerto Rican parrot. Final Report. North Carolina Cooperative Fish and Wildlife Research Unit. Raleigh, NC. 93 pp.

Collazo, J. A., T. H. White, F. J. Vilella, and S. Guerrero. 2003. Survival of captive-reared Hispaniolan Parrots released in Parque Nacional del Este, Dominican Republic. Condor 105: 198-207.

Daniels, S., S. M. Haig, and J. A. Collazo. 2001. Preliminary Pedigree Analyses for the Puerto Rican Parrot. Report to the U.S. Fish and Wildlife Service, Atlanta, GA. 35 pp.

Dennis, B., P. L. Munholland, and J. M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs 61:115-143.

Departamento de Recursos Naturales. 1990. Plan de Manejo Forestal y Vida Silvestre del Bosque Estatal de Río Abajo. Depto. Recursos Naturales, San Juan, Puerto Rico. 64 pp.

Forshaw, J. M. 1978. Parrots of the World, 2nd (rev.) ed. Melbourne: Lansdowne Ed.

Haig, S. M., and J. D. Ballou. 1995. Genetic diversity between two avian species formerly endemic to Guam. Auk 112: 445-455.

Haig, S. M. and J. D. Ballou. 2002. Pedigree analysis in wild populations. In: Population Viability Analyses (S.R. Beissinger, D.R. McCullough, eds). University of Chicago Press, pp. 388-405.

Haig, S. M., J. Collazo, H. Draheim, and S. Daniels. 2004. Population structure and pedigree definition in captive and wild Puerto Rican Parrots (*Amazona vittata*). Conservation Genetics. Report to USFWS-Rio Grande Field Office and the PR Department of Natural and Environmental Resources. 2 November. 30 pp.

Helmer, E. H., O. Ramos, T. del M. López, M. Quiñonez, and W. Díaz. 2002. Mapping the Forest Type and Land Cover of Puerto Rico, a Component of the Caribbean Biodiversity Hotspot. Caribb J. Sci. 38:165-183.

Inman, F. 2005. Canopy removal and recruitment of important food plants for the endangered Puerto Rican Parrot. M.S. Thesis, North Carolina State University, Raleigh.

Koening, S. E., J. M. Wunderle, Jr, and E. C. Enkerlin-Hoeflich. 2007. Vines and canopy contact: a route for snake predation on parrot nests. Bird Conservation International. 17:.79-91.

Lacy, R. C., N. R. Flesness, and U. S. Seal. 1989. Puerto Rican Parrot population viability analysis. Captive Breeding Specialist Group, Apple Valley, MN 55124. FWS Cooperative Agreement 14-16-0004-89-927. 97 pp.

Lindsey, G.D. 1992. Nest Guarding from observation blinds: strategy for improving Puerto Rican Parrot nest success. J. Field Ornithol. 63:466-472.

Lindsey, G. D., Arendt, W. J., and Kalina, J. 1994. Survival and causes of mortality in juvenile Puerto Rican Parrots. J. Field Ornithol. 65:76-82.

Llerandi Román, I. 2005. Red tailed Hawk home range, habitat use, and activitity patterns in moist limestone forests. M.S. Thesis. Mississippi State University. 177 pp.

Lugo, A. E., L. Miranda Castro, A. Vale, T. del Mar Lopez, E. Hernandez Prieto, A. Garcia Martino, A. R. Puente Rolon, A. G. Tossas, D. A. MacFarlane, T. Miller, A. Rodríguez, J. Lundgerg, J. Thomlinson, J. Colon, J. H. Schellekens, O. Ramos, and E. Helmer. 2001. Puerto Rican Karst-A Vital Resource. Gen. Tech. Report WO-65, USDA, US Forest Service. 100 pp.

Meyers, J. M., W. J. Arendt, and G. D. Lindsey. 1996. Survival of radio-collared nesting Puerto Rican Parrots. Wilson Bulletin 108:159-163.

Muiznieks, B. D. 2003. Population viability analysis of the Puerto Rican Parrot: an evaluation of its current status and prognosis for recovery. M.S. Thesis, North Carolina State University. 88 pp. (http://www.lib.ncsu.edu/ETD-db/ETD-browse/browse).

Murphy, L. S. 1916. Forests of Porto Rico, past, present and future, and their physical and economic environment. USDA Agricultural Bulletin No. 354, Washington, D.C. 99 pp.

Nimitz, W. F. 2005. Habitat use and activity patterns of Red-tailed Hawks in occupied and historic Puerto Rican Parrot habitat. M.S. Thesis. Mississippi State University. 130 pp.

Rivera-Milan, F. F. 1995. Distribution and abundance of raptors in Puerto Rico. Wilson Bull. 107:452-462.

Snyder, N. F. R., and J. D. Taapken. 1977. Puerto Rican parrots and nest predation by Pearly-eyed Thrashers. Pp. 113-121 *In* S. A. Temple (ed.), Endangered Birds. Univ. Wisconsin Press, Madison, Wisconsin.

Snyder, N. F. R., J. W. Wiley, and C. B. Kepler. 1987. The parrots of Luquillo. West. Found. Vert. Zool., Los Angeles. 384 pp.

Soule, M. E., M. Gilpin, W. Conway, and T. J. Foose. 1986. The millennium ark: how long a voyage, how many staterooms, how many passengers? Zoo Biology 5:101-113.

Thompson-Baranello, J. J. 2000. Resource and population modeling of the Puerto Rican parrot (*Amazona vittata*). M.S. Thesis. University of Puerto Rico, Río Piedras Campus.

Trujillo, A. M. 2005. Evaluation of the suitability of the karst region of north-central Puerto Rico for the reintroduction of Puerto Rican Parrot (*Amazona. vittata*). M.S. Thesis, University of Puerto Rico, Mayagüez Campus.

U.S. Fish and Wildlife Service. 1982. Puerto Rican Parrot Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 44 pp.

U.S. Fish and Wildlife Service. 1986. Technical/Agency Draft Revised Recovery Plan for the Puerto Rican Parrot (*Amazona vittata*). Atlanta, Georgia. 21 pp.

U.S. Fish and Wildlife Service. 1999. Technical/Agency Draft Revised Recovery Plan for the Puerto Rican Parrot (*Amazona vittata*). Atlanta, Georgia. 77 pp.

Wadsworth, F. H. 1949. The development of the forest land resources of the Luquillo Mountains. Ph.D. Dissertation, Univ. Michigan, Ann Arbor. 481 pp.

Wadsworth, F. H. 1951. Forest management in the Luquillo Mountains, I. The setting. Caribbean Forests 12:92-114.

White, T. H., G. G. Brown, and J. A. Collazo. 2006. Artificial cavities and nest site selection by Puerto Rican Parrots: a multiscale assessment. Avian Conservation and Ecology - Écologie et conservation des oiseaux 1(3): 5. [online] URL: http://www.ace-eco.org/vol1/iss3/art5/.

White, T. H., Jr., F. J. Vilella, J. A. Collazo, and S. A. Guerrero. 2005c. Effects of Hurricane Georges on habitat use by captive-reared Hispaniolan Parrots released in the Dominican Republic. Ornitologia Neotropical.16(3): 405-418

White, T. H., Jr. and F. J. Vilella. 2004. Nest management for the Puerto Rican Parrot (*Amazona vittata*): gaining the technological edge. Ornitología Neotropical 15 (suppl.):467-476.

White, T. H., Jr., J. A. Collazo, and F. J. Vilella. 2005a. Survival of captive-reared Puerto Rican Parrots released in the El Yunque National Forest. Condor 107:426-434.

White, T. H., Jr., W. Abreu-González, Miguel Toledo-González, Pablo Torres-Báez 2005b. From the Field: Artificial nest cavities for Amazona parrots. Wildl. Soc. Bull. 33:765-760.

Wiley, J. W. 1980. The Puerto Rican Amazon (*Amazona vittata*): Its decline and the program for its conservation. Pp. 133-15g *In* R. F. Pasquier, ed., Conservation of New World Parrots. International Council for Bird Preservation. Tech. Publ. No.1.

Wiley, J. W. 1985. The Puerto Rican parrot and competition for its nest sites. Pp. 213-223 *In* P. J. Moore (ed.), Conservation of Island Birds. ICBP Tech. Publ. No. 3.

Wiley, J. W. and J. Wunderle 1993. Hurricane effects on bird populations in general. Bird Conservation International 3:319-349.

Wiley, J. W., R. S. Gnam, S. E. Koenig, A. Dornelly, X. Galvez, P. E. Bradley, T. White, M. Zamore, P. Reillo, and D. Anthony. 2004. Status and conservation of the family Psittacidae in the West Indies. J. Caribbean Ornithology (Special Issue Honoring Nedra Klein) :94-154.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2001. Analysis and Management of Animal Populations. Academic Press, San Diego, CA. 817 pp.

Wunderle, J. M., Jr., N. F. R. Snyder, B. D. Muiznieks, J. W. Wiley, and J. M. Meyers. 2003. Histories of Puerto Rican parrot nests in the Caribbean National Forest/Luquillo Experimental Forest 1973-2000. General Technical Report IITF-GTR-21. Rio Piedras, Puerto Rico, U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry. 28 p.

Wunderle, J. M., Jr., J. E. Mercado, B. Parreso, and E. Terranova. 2004. Spatial Ecology of Puerto Rican Boas (*Epicrates inornatus*) in a Hurricane Impacted Forest. Biotropica 36:555-571.

Appendices

Appendix 1. Historical summary of minimum counts of Puerto Rican parrots from 1954 to 2007 in YNF, Luquillo Mountains. The month in which the surveys were conducted is indicated parenthetically. Since 1990 pre- and post-breeding surveys were consistently conducted. Pre-breeding surveys are generally conducted early in the year; post-breeding in mid to late summer. Personnel conducting surveys prior to 1989 are identified by Snyder et al. 1987. Since 1989, surveys have been conducted and coordinated by personnel with the RGFO.

Year (month)	**Count**
1954 (October)	200
1963 (May)	130
1966 (December)	70
1968 (November)	24
1971 (January)	16
1975 (March)	14
1975 (May)	13
1980 (January)	19
1982 (July)	29
1985 (July)	35

Year	Pre-breeding Count	Post-breeding Count
1986	29 (April)	31 (August)
1986		31 (November)
1989	*	47 (August [bH])
1989	*	23 (September [aH])
1990	24 (January)	21 (September)
1991	24 (April)	30 (September)
1992	24 (February)	28 (October)
1993	34 (January)	42 (September)
1994	38 (March)	40 (August)
1995	33 (February)	44 (September)
1996	38 (January)	42 (August)
1997	40	40 (July)
1998	42 (March)	36 (September [aG])
1999	38	38 (May)
2000		21 (September)

2001	28 (March)	31 (September)
2002	21 (March)	28 (July)
2003	24 (March)	17
2004	26 (March)	31 (July)
2005	27 (March)	17 (August)
2006	16 (February)	23 (June)
2007	18 (January-February)	25 (July)

[bH] before hurricane Hugo, [aH] after hurricane Hugo, [aG] After hurricane Georges,
* count not conducted

Appendix 2. Productivity of the captive Puerto Rican parrots in the Luquillo Aviary (LU) from 1979 to 2007, and the J. L. Vivaldi (RA) Aviary since 1994. Detailed histories for each parrot in the aviary are contained in the SPARKS database created for both aviaries (Daniels et al. 2001), which resides with RGFO. DIS means "dead in shell."

Year	Aviary	#Pairs	Total Eggs	Fertile Eggs	Infertile Eggs	Unknown Eggs	Deaths	DIS	Hatchlings Produced	Fledglings Produced	Birds Released
1979	LU		6	1	5				1	1	
1980	LU		23	6	17				3	2	
1981	LU		22	7	15				4	2	
1982	LU		59	19	40				5	5	
1983	LU		43	10	33				8	7	
1984	LU		34	11	23				7	7	
1985	LU		49	13	36				11	8	
1986	LU		53	11	42				4	3	
1987	LU		37	13	24				4	4	
1988	LU		66	21	45				14	8	
1989	LU	17	59	16	43	0	3	7	9	6	
1992	LU	12	41	11	30	0	1	9	2	1	
1993	LU	13	42	17	19	6	1	10	7	6	
1994	LU	13	61	14	41	6	2	5	9	8	
1994	RA	5	19	6	12	1	0	4		2	
1995	LU	9	39	12	24	3	5	5	7	8	
1995	RA	6	31	16	12	3	3	4		9	
1996	LU	12	40	18	22	0	4	11	7	3	
1996	RA	11	43	22	18	3	4	10		10	
1997	LU	11	41	13	25	3	1	7	6	5	
1997	RA	14	39	22	16	1	3	15		4	
1998	LU	11	39	14	22	3	5	7	7	4	
1998	RA	12	43	13	25	5	0	3		10	
1999	LU		37	6	23	8	1	2	4	3	
1999	RA	16	45	20	25	0	0	7		13	
2000	LU	10	51	22	20	9	2	15	7	6	6
2000	RA	17	67	28	35	1	4	9	18	16	4
2001	LU	16	42	11	28	2	3	3	8	6	5
2001	RA	19	58	27	26	5	2	11	16	14	11
2002	LU	18	49	12	31	6	1	6	6	5	7
2002	RA	19	81	32	42	7	4	12	0	16	2
2003	LU	11	53	24	27	2	7	9	13	7	
2003	RA	17	88	27	49	12	16	16	11	11	
2004	LU	13	55	21	30	4	6	5	16	10	5
2004	RA	15	80	29	40	10	13	13	16	11	
2005	LU	14	55	23	38	0	4	8	14	10	
2005	RA	20	73	30	33	10	4	13	16	12	

Year	Aviary	#Pairs	Total Eggs	Fertile Eggs	Infertile Eggs	Unknown Eggs	Deaths	DIS	Hatchlings Produced	Fledglings Produced	Birds Released
2006	LU	13	69	41	25	3	1	3	14	13	
2006	RA	29	120	57	53	10	3	25	32	29	22
2007	LU	14	66	33	31	2	3	11	19	22	
2007	RA	27	113	65	39	9	1	27	36	31	

Appendix 3. Input parameter values used for BASE for Vortex simulations in 2002. (Definitions for each parameter are outlined in Miller and Lacy (1999))

BASE2002.OUT ***Output Filename***
Y ***Graphing Files?***
N ***Details each Iteration?***
1000 ***Simulations***
100 ***Years***
10 ***Reporting Interval***
0 ***Definition of Extinction***
1 ***Populations***
N ***Inbreeding Depression?***
Y ***EV concordance between repro and surv?***
1 ***Types Of Catastrophes***
M ***Monogamous, Polygynous, or Hermaphroditic***
4 ***Female Breeding Age***
4 ***Male Breeding Age***
18 ***Maximum Breeding Age***
50.000000 ***Sex Ratio (percent males)***
0 ***Maximum Litter Size (0 = normal distribution) *****
N ***Density Dependent Breeding?***
YNF
50.00 **breeding
12.50 **EV-breeding
1.560000 ***YNF: Mean Litter Size***
1.210000 ***YNF: SD in Litter Size***
60.000000 *FMort age 0
13.900000 ***EV
15.200000 *FMort age 1
6.950000 ***EV
15.200000 *FMort age 2
6.950000 ***EV
15.200000 *FMort age 3
6.950000 ***EV
8.700000 *Adult FMort
3.470000 ***EV
60.000000 *MMort age 0
13.900000 ***EV
15.200000 *MMort age 1
6.950000 ***EV
15.200000 *MMort age 2
6.950000 ***EV
15.200000 *MMort age 3
6.950000 ***EV
8.700000 *Adult MMort
3.470000 ***EV
3.000000 ***Probability Of Catastrophe 1***
0.600000 ***Severity--Reproduction***
0.600000 ***Severity--Survival***
N ***All Males Breeders?***
50.000000 ***Percent Males In Breeding Pool***
Y ***Start At Stable Age Distribution?***
40 ***Initial Population Size***
500 ***K***
0.000000 ***EV--K***
N ***Trend In K?***
N ***Harvest?***
N ***Supplement?***
N ***AnotherSimulation?***

Appendix 4. *Base Model Defined*. Muiznieks (2003) used Program *Vortex* to assess the status of the parrots (e.g., probability of survival over 100 years) and conducted a sensitivity analysis to assess the relative importance of selected parameters in the demography of the species. *Vortex* models a number of demographic, environmental and genetic parameters relevant to assessments of the viability of endangered species via stochastic simulations (Miller and Lacy 1999). The status assessment was conducted by creating a BASE model. The BASE model also facilitated interpretation of results (e.g., other scenarios). This model reflected the current understanding of vital parameters and factors influencing the Puerto Rican Parrots (as of 2002). Our understanding since 1989 improved for the following parameters: first year mortality rate, age of first breeding, impact of hurricanes, and breeding productivity (Snyder et al. 1987; Lindsey et al. 1994, USFWS 1999, Collazo et al. 2000; Wunderle et al. 2002, White et al. 2005). Unfortunately, our understanding of the remaining input parameters since then has not changed, and hence, a range of values listed in Lacy et al. (1989) are used. The number and definitions for each parameter are outlined in Miller and Lacy (1999). One-thousand simulations were ran for each model and each simulation covered a span of 100 years. The mean population size of extant and extinct populations (SD), mean stochastic rate of growth (SD), mean size of extant populations (SD), and persistence probability every 10 years (graphically) and at the end of 100 years (tabular) were reported in this Recovery Plan and in Muiznieks (2003).

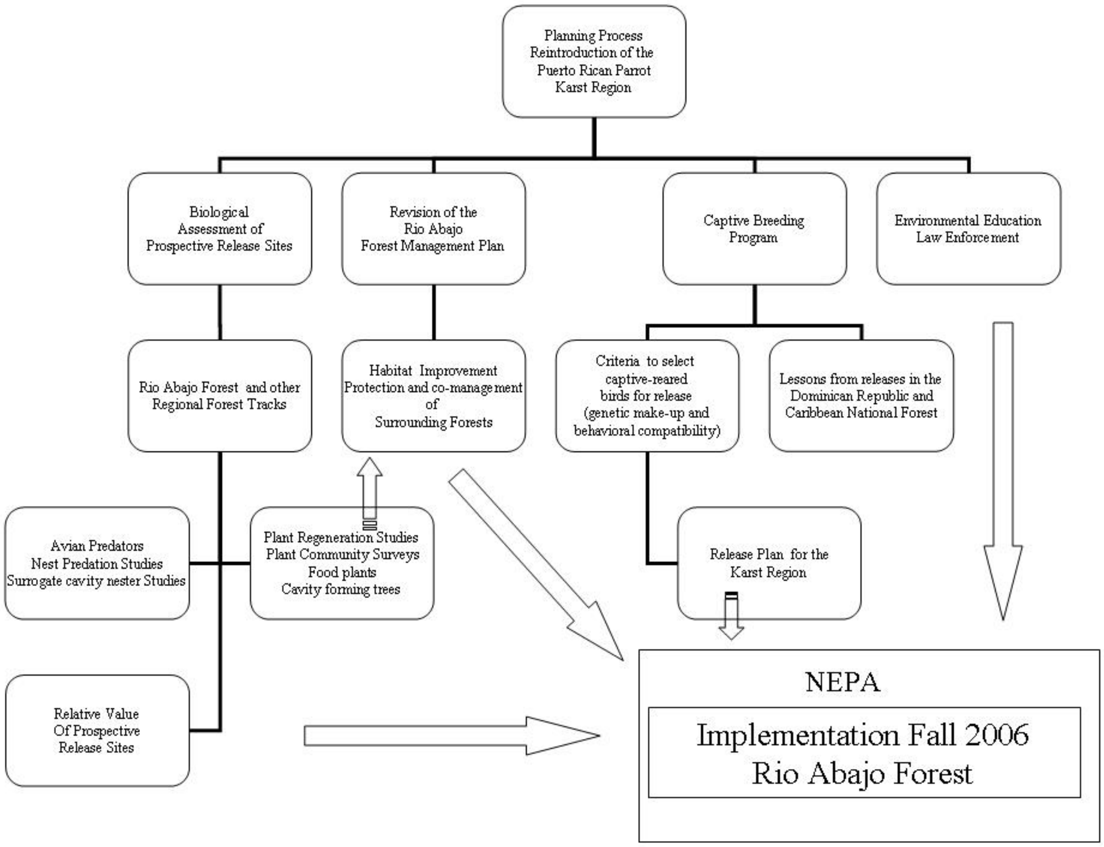
The following is a breakdown of values for selected input parameters for the BASE model, and when appropriate, a rationale to justify them is provided. Inbreeding depression was not incorporated into any model (no evidence for it, Haig et al. in prep.). Hurricanes were modeled with a probability of occurrence of 3%, the probability of Puerto Rico being hit by a major hurricanes (category 4) over 100 year period (Lacy et al. 1989). It was assumed that sex ratios at birth were 50:50 and that percent of adult females and males breeding each year was 50% (sensu Lacy et al. 1989). Because current population levels are well below historical levels (Rodríguez-Vidal 1959), and because it is believed that food is not limiting the population (Thompson-Baranello 2000), density-dependence was not included in the models. Carrying capacity was set at 500 or ¼ the number of birds occurring in the Luquillo Mountains in the 1940's (Rodríguez-Vidal 1959, Lacy et al. 1989). For breeding productivity, the most recent estimate (1990 to 2002), or 1.56 (SD = 1.21), was used. This estimate is not statistically different from the historic average of 1.48 (SD = 1.26). However, it was felt that the most recent was the appropriate for assessing current status and outlook. For juvenile survival, the average estimate of 32.5, 50, 70, and 87.5%, or 60% (SD = 23.89) was used. This average was obtained from available literature (Snyder et al. 1987), reanalysis of published data (Lindsey et al. 1994), and from ongoing telemetry studies (White et al. 2005). In the absence of data, mortality rates of sub-adults were kept constant at 15.2% and of adults at 8.7% (Snyder *et al*. 1987). For "severity with respect to reproduction" after a hurricane, 0.60 (or reduction of 40%) was used. This estimate was based on the effect Hurricane Hugo on productivity in 1990. "Severity with respect to survival" was set at 0.60 based on pre-breeding surveys in 1989 and post-hurricane surveys, and at 0.50 based on post-breeding and post-hurricane surveys (Lindsey 1992, USFWS 1999). A 25% coefficient of variation was assigned to all parameters except for breeding productivity for which the estimated sample variance was used.

Appendix 5. Input parameter values used for the BASE for Vortex simulations in 1989. (Definitions for each parameter are outlined in Miller and Lacy (1999))

BASE1989.OUT ***Output Filename***
Y ***Graphing Files?***
N ***Details each Iteration?***
1000 ***Simulations***
100 ***Years***
10 ***Reporting Interval***
0 ***Definition of Extinction***
1 ***Populations***
N ***Inbreeding Depression?***
Y ***EV concordance between repro and surv?***
1 ***Types Of Catastrophes***
M ***Monogamous, Polygynous, or Hermaphroditic***
4 ***Female Breeding Age***
4 ***Male Breeding Age***
18 ***Maximum Breeding Age***
50.000000 ***Sex Ratio (percent males)***
0 ***Maximum Litter Size (0 = normal distribution) *****
N ***Density Dependent Breeding?***
Pop1
51.40 **breeding
12.00 **EV-breeding
1.410000 ***Pop1: Mean Litter Size***
1.310000 ***Pop1: SD in Litter Size***
32.500000 *FMort age 0
13.900000 ***EV
15.200000 *FMort age 1
6.950000 ***EV
15.200000 *FMort age 2
6.950000 ***EV
15.200000 *FMort age 3
6.950000 ***EV
8.700000 *Adult FMort
3.400000 ***EV
32.500000 *MMort age 0
13.900000 ***EV
15.200000 *MMort age 1
6.950000 ***EV
15.200000 *MMort age 2
6.950000 ***EV
15.200000 *MMort age 3
6.950000 ***EV
8.700000 *Adult MMort
3.400000 ***EV
3.000000 ***Probability Of Catastrophe 1***
0.000000 ***Severity--Reproduction***
0.500000 ***Severity--Survival***
N ***All Males Breeders?***
50.000000 ***Percent Males In Breeding Pool***
Y ***Start At Stable Age Distribution?***
40 ***Initial Population Size***
500 ***K***
0.000000 ***EV--K***
N ***Trend In K?***
N ***Harvest?***
N ***Supplement?***
N ***AnotherSimulation?***

Appendix 6. *Sensitivity Analysis Defined* – Muiznieks (2003) evaluated 7 parameters using 1440 permutations. Parameters of primary interest were: age of first breeding (AFB), maximum breeding age (MBA), productivity, juvenile mortality rates (J mort), adult mortality (A mort), percent of breeding females in the population (%Br), and hurricane severity (Hurr. Sev.) with respect to reproduction. Sensitivity was expressed as the mean stochastic growth rate for a given parameter. The estimate was obtained by sorting by the parameter of interest, and then, averaging across all possible permutations or model scenarios. Values for age of first breeding varied from 3 (age at first breeding observed in the aviary) to 4 and 5, age at first breeding observed in the wild (Meyers and Lindsey 1996; unpub. data, USFWS). For maximum breeding age, ages 16 and 18 were used, values that emerged from consensus (Lacy et al. 1989). Muiznieks (2003) used all available estimates of juvenile mortality (i.e., 32.5, 50, 70, 87.5%), and used three values for adult mortality, that is, 8.7%, 11%, and 15%. The range reflects values reported in the literature (Snyder et al. 1987, Lacy et al. 1989) and it is anticipated to encompass suspected increase in adult mortality due to Red-tailed hawk predation in recent years (T. White, USFWS-Rio Grande Field Office, pers. comm. 2007). It was assumed that the percent of adult females and males breeding each year ranged between 50% and 60%, encompassing the ranged used by Lacy et al. (1989). For “severity with respect to reproduction” after a hurricane, Muiznieks (2003) used 0.50 and 0.60 (or reduction of 40%), the estimate based on the effect Hurricane Hugo on productivity in 1990. For breeding productivity, two expressions of productivity to generate numeric contrast using the same data set were used. The first one was the mean production per nesting attempt (1.56, SD = 1.21) from 1990 to 2002; the second was the mean production per successful nest (2.3, SD = 0.65) for the same time period.

Appendix 7. Flow chart listing the various studies and sources of information used to evaluate potential release sites, including RAF, and to develop a reintroduction plan to establish the second wild population of Puerto Rican parrots in the island. The RAF (2,340 ha), and surrounding forests, ranked 1 among 3 potential release sites (protected areas) in the northwestern karst (limestone) region of Puerto Rico.



List of Stakeholders* / Reviewers(#)

Hon. Javier Vélez Arocho *
Secretary
Department of Natural and Environmental Resources
P.O. Box 366147
San Juan, Puerto Rico 00936

Dr. Miguel García (#)
Terrestrial Ecology Section
Department of Natural and Environmental Resources
P.O. Box 366147
San Juan, Puerto Rico 00936

Mr. José L. Chabert (#)
Department of Natural and Environmental Resources
P.O. Box 366147
San Juan, Puerto Rico 00936

Mr. Ricardo Valentín (#)
Department of Natural and Environmental Resources
P.O. Box 439
Arecibo, Puerto Rico 00613-0439

Mr. Pablo Cruz *
U.S. Forest Service
HC-01 Buzon 13490
Rio Grande, PR 00745

Mr. Pedro Rios (#)
U.S. Forest Service
HC-01 Buzon 13490
Rio Grande, PR 00745

Dr. Joseph M. Wunderle (#)
U.S. Forest Service
HC-01 Buzon 13490
Rio Grande, PR 00745

Dr. Ariel Lugo *
Institute of Tropical Forestry
U.S. Forest Service
Call Box 25000, Experimental Station
Río Piedras, P.R. 00928

Dr. Rosemary Gnam (#)
Office of Management Authority
U.S. Fish and Wildlife Service
4401 N. Fairfax Drive
Arlington, VA 22201

Dr. Marcia Wilson (#)
Biological Resources Division
Patuxent Environmental Science Center
Laurel, MD 20708

Ms. Donna Ball (#)
U.S. Fish and Wildlife Service
Kona Forest National Wildlife Refuge
P.O. Box 244
Honaunau, HI 96726

Mr. William C. Hunter (#)
U.S. Fish and Wildlife Service
Refuges and Wildlife
1875 Century Boulevard
Atlanta, Georgia 30345

Dr. Joshua Dein (#)
National Wildlife Health Center
Animal Welfare Officer
6006 Schroeder Road
Madison, WI 53711

Ms. Marelisa Rivera (#)
U.S. Fish and Wildlife Service
P.O. Box 491
Boquerón, P.R. 00622

Mr. Carl A. Soderberg *
Director
U.S. Environmental Protection Agency
Centro Europa Building
1492 Ponce De Leon Avenue, Suite 417
San Juan, PR 00907-4127

Director *
Rural Development
GPO Box 366106
San Juan, P.R. 00936-6106

Mr. Sindulfo Castillo *
Chief Regulatory Section
U.S. Army Corps of Engineers
400 Fernandez Juncos Ave.
San Juan, P.R. 00909

Mr. Juan Martinez *
Natural Resources Conservation Service
Caribbean Area Service
IBM Plaza Suite 604
Hato Rey, P.R. 00918-4123

Ing. Roberto Fonseca *
Federal Highway Administration
Federal Building - Room 329
Carlos Chardon Street
Hato Rey, P.R. 00918

Director *
Housing and Urban Development
Caribbean Office
159 Carlos Chardon Avenue
Hato Rey, P.R. 00918

Mr. Fernando Lloveras *
Puerto Rico Conservation Trust
Box 4747
San Juan, P.R. 00902

Mark Stafford (#)
Parrot International
438 MT. Holyoke
Pacific Palisades, CA 90272

Mr. Herbert A. Raffaele (#)
5232 Cherokee Avenue
Alexandria, VA 22312

President *
Environmental Quality Board
P.O. Box 11488
Santurce, P.R. 00907-08

Mr. Angel Cintrón *
President
Puerto Rico Planning Board
P.O. Box 41119
San Juan, P.R. 00940

Hon. Edwin Rivera Correa *
Mayor
Municipality of Rio Grande
P.O. Box 847
Rio Grande, P.R. 00745

Hon. Jose Gonzalez Ortiz *
Mayor
Municipality of Luquillo
P.O. Box 1012
Luquillo, P.R. 00773

Hon. Wilfredo Astacio Santiago *
Mayor
Municipality of Naguabo
P.O. Box 40
Naguabo, P.R. 00718

Hon. Luis O. Maldonado *
Mayor
Municipality of Ciales
P.O. Box 1408
Ciales, P.R. 00638

Hon. Alan Gonzalez Cancel *
Mayor
Municipality of Utuado
P.O. Box 190
Utuado, P.R. 00641

Dr. James W. Wiley (#)
Grambling State University
Cooperative Fish and Wildlife Research Unit
2201 Ashland Street
Ruston, Louisiana 71270

Dr. Francisco Vilella (#)
Mississippi State Cooperative Fish and Wildlife Research Unit
Mississippi State University
School of Forest Resources
Forest and Wildlife Research Center
Mississippi State, Mississippi 39762

Dr. Enrique Hernandez-Prieto (#)
University of Puerto Rico
Humacao Campus
Biology Department
Humacao, Puerto Rico 00971

Dr. Cameron Kepler (#)
USGS/Biological Resources Division
Warnell School of Forestry Research
University of Georgia
Athens, GA 30602-2152

Dr. Carlos Delannoy (#)
Department of Biology
University of Puerto Rico
Mayagüez Campus
P.O. Box 5000
Mayaguez, PR 0681

Mr. Raúl Pérez (#)
Biology Department
University of Puerto Rico
Humacao Campus
Humacao, P.R. 00971

Mr. Antonio Rivera, D.M.V. (#)
1834 Glasbow Avenue
College Park
Rio Piedras, PR 00921

Mr. Simón Guerrero (#)
Parque Zoológico Nacional
Santo Domingo, República Dominicana

Mr. Antonio Rodriguez-Vidal (#)
San Patricio Ave. #788
Rio Piedras, P.R. 00921

Dr. Noel Snyder [(#)]
WPTI
P.O. Box 426
Portal, AZ 85632